# TRANSACTIONS and PROCEEDINGS

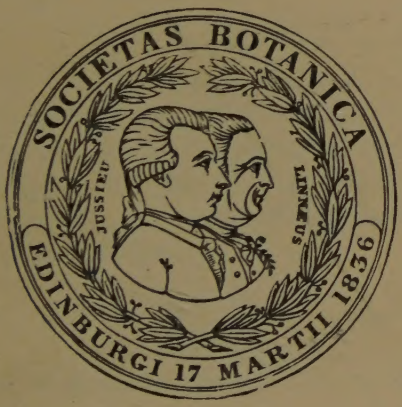
OF THE

# BOTANICAL SOCIETY OF EDINBURGH

VOLUME XXXVII

Part IV

SESSION 1957-58

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1959

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# PROCEEDINGS

OF THE

# BOTANICAL SOCIETY OF EDINBURGH

## SESSION CXXII

*OCTOBER* 10, 1957.

Dr. H. R. FLETCHER, President, in the Chair.

Mr. W. E. S. BROCKBANK, Mr. J. L. MOWAT, Mr. J. L. KEPPIE, Dr. D. C. WEEKS, Mr. W. G. SUTTON and Mr. R. B. KNOX were elected Ordinary Fellows and Mr. K. W. ROSS was elected an Ordinary Member.

Mr. J. M. TODD delivered a lecture entitled "Some Aspects of the Natural History of Viruses".

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*OCTOBER* 29, 1957.

Dr. H. R. FLETCHER, President, in the Chair.

The Wright Smith Lecture was delivered by Professor IRENE MANTON. Her subject was "The Modern Era in Microscopy: A Survey of some Aspects of Plant Cell Structure when Viewed with the Electron Microscope".

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*NOVEMBER* 14, 1957.

Dr. H. R. FLETCHER, President, in the Chair.

Miss R. M. SMITH, Dr. D. R. EGOLF and Mr. W. MARSHALL were elected Ordinary Fellows and Mrs. BEATRIX FARRAND was elected a Lady Member.

Dr. FLETCHER then inaugurated the special series of lectures on *History and Developments in Scottish Botany* by reading a paper entitled "The Exploration of the Scottish Flora".

At the conclusion of the public business a meeting was held to discuss the formation of an Alpine Section of the Botanical Society, comparable with the Cryptogamic Section. Mr. J. Grant Roger was elected Secretary of the Section and plans were made to arrange two excursions in the summer of 1958. (*See* p. 293).

*NOVEMBER* 26, 1957.

Dr. H. R. FLETCHER, President, in the Chair.

Dr. J. A. SWORD addressed the meeting on "Grain Varieties: Differences in their Behaviour in the Field, in the Mill and on the Table".

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*DECEMBER* 12, 1957.

Dr. H. R. FLETCHER, President, in the Chair.

Miss P. M. LEWIS, Miss E. WHITTAKER, Mr. G. R. MILLER, Mr. A. A. PARDY, Mr. N. M. PRITCHARD, Mr. R. W. M. CORNER, Mr. R. FAULKNER, Mr. W. A. HUGHES and Mr. J. GORDON URQUHART were elected Ordinary Fellows; Miss M. BEATTIE, Miss K. PATON, Mr. R. WHITE and Mr. R. K. MARTIN were elected Ordinary Members.

*History and Developments in Scottish Botany*, II. Mr. D. M. HENDERSON discussed "The Discovery of the Non-flowering Plants".

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*JANUARY* 9, 1958.

Dr. H. R. FLETCHER, President, in the Chair.

Mr. J. C. STORMONTH DARLING, Dr. SCOTT M. WYLIE, Mr. D. WELLS and Dr. DENIS RATCLIFFE were elected Ordinary Fellows; Mrs. E. HENMAN, Mrs. I. WRIGHT and Mr. D. W. STEWART were elected Ordinary Members.

*History and Developments in Scottish Botany*, III. Dr. W. A. CLARK gave a lecture entitled "Recent Discoveries in the Flora".

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*JANUARY* 28, 1958.

Dr. H. R. FLETCHER, President, in the Chair.

The business of the meeting consisted of two short papers:
"Under-water Botany", by Mr. W. MARSHALL, and
"Study in the Physiological Basis of Plant Ecology and Distribution", by Dr. DENIS RATCLIFFE.

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*FEBRUARY* 20, 1958.

Dr. H. R. FLETCHER, President, in the Chair.

Mr. A. C. HOPEKIRK was elected an Ordinary Member.

*History and Developments in Scottish Botany*, IV. Dr. HARRY GODWIN gave a lecture entitled "The History of the Flora from the Ice Age".

*MARCH* 1, 1958.

Dr. H. R. Fletcher, President, in the Chair.

A joint meeting of the Botanical Society of Edinburgh and the Andersonian Natural History Society was held in the Department of Botany, Glasgow University. Two papers were read: "Botanising in the Hebrides", by Dr. W. A. Clark, and "Nitrogen Fixation in Plants", by Dr. G. Bond.

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*MARCH* 4, 1958.

Dr. D. H. N. Spence, Vice-President, in the Chair.

Mr. R. E. C. Ferreira gave a lecture entitled "Inter-relationships of the Scottish Mountain Flora and Geology".

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*MARCH* 13, 1958.

Mr. R. M. Adam, Vice-President, in the Chair.

Miss J. M. Lamond, Miss C. M. Matheson and Mr. G. L. Allen were elected Ordinary Fellows and Mrs. Ines Allen was elected an Ordinary Member.

*History and Developments in Scottish Botany,* V. Dr. C. E. Foister gave a lecture entitled "Progress in Mycology".

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*APRIL* 17, 1958.

Dr. H. R. Fletcher, President, in the Chair.

Dr. A. J. Smith and Dr. S. R. Chant were elected Ordinary Fellows.

*History and Developments in Scottish Botany,* VI. Professor John Walton gave a lecture entitled "The Study of Fossil Plants".

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*MAY* 8, 1958.

Dr. H. R. Fletcher, President, in the Chair.

Mr. B. Flannigan was elected an Ordinary Member.

*History and Developments in Scottish Botany,* VII. Mr. J. Grant Roger gave a lecture entitled "Conservation and the Future of the Flora".

*MAY* 30, 1958.

Dr. H. R. Fletcher, President, in the Chair.

A meeting of the Society was held in the Department of Botany, Aberdeen University, at which Mr. J. Grant Roger spoke on "The Flora of North-east Scotland".

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*JUNE* 19, 1958.

Dr. H. R. Fletcher, President, in the Chair.

Dr. J. Harper and Mr. J. Bruce were elected Ordinary Fellows.

The following Office-Bearers were elected for Session 1958-59:

**PRESIDENT**

H. R. Fletcher, Ph.D., D.Sc., F.R.S.E., V.M.H.

**VICE-PRESIDENTS**

R. M. Adam, F.L.S.
C. E. Foister, B.A., Ph.D., Dip. Ag. Sci., F.R.S.E.
Miss M. M. Macdonald, B.Sc.
Miss Patricia J. Watson, Ph.D.

**COUNCILLORS**

H. H. Davidian, B.Sc.
W. A. Clark, B.Sc., Ph.D.
C. H. Gimingham, B.Sc., Ph.D.
L. S. Cobley, B.Sc.
Miss Lucy Boyd, D.Sc.
Miss Muriel Hay, B.Sc.
J. G. Dodds, Ph.D.
B. W. Ribbons, B.Sc., F.L.S.
R. L. Scarlett, C.B.E., C.D.A.
D. H. N. Spence, Ph.D.

*Honorary Secretary*—P. S. Green, B.Sc., F.L.S.

*Assistant Secretary*—Miss D. E. Purves.

*Cryptogamic Secretary*—D. M. Henderson, B.Sc.

*Alpine Botanical Secretary*—J. Grant Roger, B.Sc., F.L.S.

*Editor*—Miss A. M. MacLeod, B.Sc., Ph.D. (Heriot-Watt College, Edinburgh).

*Treasurer*—R. T. Hunter, C.A.

*Auditor*—John Turnbull, C.A.

The TREASURER, Mr. R. T. HUNTER, submitted the following Statement of Accounts for the Session 1957-1958:

INCOME.

| | | | |
|---|---|---|---|
| Annual Subscriptions | £148 | 0 | 0 |
| Arrears of Subscriptions recovered | 28 | 0 | 0 |
| *Transactions* sold | 101 | 17 | 1 |
| Interest on Investments | 27 | 10 | 6 |
| Subscriptions to Publications Fund | 0 | 0 | 0 |
| Income from Botanical Society Trust Fund | 12 | 13 | 0 |
| Income Tax Recovered, 1957/58 | 15 | 16 | 4 |
| Transferred from Capital Fund | 53 | 2 | 0 |
| | £386 | 18 | 11 |

EXPENDITURE.

| | | | |
|---|---|---|---|
| Printing *Transactions*, Vol. 37 (Part II) | £156 | 16 | 6 |
| Printing Billets, etc. | 135 | 11 | 10 |
| | £292 | 8 | 4 |
| Stationery, Postages, etc. | 23 | 15 | 8 |
| Fire Insurance on Books | 0 | 5 | 0 |
| Projector and Film | 6 | 13 | 0 |
| Bank Charges | 2 | 2 | 8 |
| Lecture Expenses and Social Evening | 7 | 11 | 2 |
| Honoraria to Treasurer and Assistant Secretary | 10 | 10 | 0 |
| Donation to George Don Memorial | 5 | 10 | 0 |
| Excess of Income over Expenditure | 38 | 3 | 1 |
| | £386 | 18 | 11 |

## BALANCE SHEET AT 30TH APRIL 1958.

### LIABILITIES.

| | | | | | |
|---|---|---|---|---|---|
| I. Capital Funds— | | | | | |
| Balance brought forward from 1956/57 ... ... | | | | £1047 | 17 1 |
| *Add*—Life Composition received in 1957/58 ... ... ... | £6 | 12 | 9 | | |
| Donations ... ... ... ... | 2 | 1 | 9 | | |
| Sale of Scrap Lead ... ... ... | 5 | 5 | 8 | | |
| | | | | 14 | 0 2 |
| | | | | £1061 | 17 3 |
| Transferred to Revenue 5% of £1061 17s 3d ... | | | | 53 | 2 0 |
| | | | | £1008 | 15 3 |
| *Add*—Excess of Income over Expenditure, 1957/58 | | | | 38 | 3 1 |
| | | | | £1046 | 18 4 |
| II. Subscriptions received in advance— | | | | | |
| 1959/60. E. W. Debney ... ... ... | £1 | 0 | 0 | | |
| 1958/59. J. G. Roger ... ... ... | 1 | 0 | 0 | | |
| L. A. Lauener ... ... ... | 1 | 0 | 0 | | |
| J. C. Brownlie ... ... | 1 | 0 | 0 | | |
| Mrs. J. Norman Hendry ... | 0 | 10 | 0 | | |
| E. W. Debney ... ... ... | 1 | 0 | 0 | | |
| | | | | 5 | 10 0 |
| III. Accounts Outstanding— | | | | | |
| Sum due to Matthews Volume Fund ... ... ... | | | | 1 | 0 0 |
| | | | | £1053 | 8 4 |

### ASSETS.

| | | | | | |
|---|---|---|---|---|---|
| I. British Government Securities— | | | | | |
| (a) £200 3½% War Stock at cost ... ... ... | | | | £194 | 18 3 |
| (b) £258 2s 6d British Transport 3% Guaranteed Stock 1978/88 at cost ... ... ... ... | | | | 216 | 18 6 |
| (c) £100 4% Defence Bonds (Conversion Issue) at cost ... ... ... ... ... ... ... | | | | 100 | 0 0 |
| (d) £100 3½% Defence Bonds (Conversion Issue) at cost ... ... ... ... ... ... ... | | | | 100 | 0 0 |
| (e) £250 3% Savings Bonds 1965/75 at cost ... | | | | 253 | 18 3 |
| | | | | £865 | 15 0 |
| II. Bank Balances— | | | | | |
| (a) Sum on Current Account with Clydesdale & North of Scotland Bank, Ltd. ... ... ... | £13 | 2 | 2 | | |
| (b) Savings Account—Bank of Scotland | 42 | 0 | 9 | | |
| (c) Edinburgh Savings Bank Account No. 129 ... ... ... ... | 116 | 14 | 1 | | |
| | | | | 171 | 17 0 |
| III. Grant due from Carnegie Trust ... ... ... | | | | 0 | 0 0 |
| IV. Income Tax Reclaim, 1957/58 ... ... ... ... | | | | 15 | 16 4 |
| | | | | £1053 | 8 4 |

(Sgd.) RONALD T. HUNTER, C.A., Treasurer.

EDINBURGH, 16th May 1958.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for the Session 1957/58 and have found them correct. I have also checked the foregoing Abstract and found it correct. I have seen the Securities for the Invested Funds and found them in order.

(Sgd.) CHARLES A. SCOTT, C.A., Auditor.

## SIR WILLIAM WRIGHT SMITH LECTURESHIP FUND.

SESSION 1957/58.

| | | | |
|---|---|---|---|
| Balance of Fund brought forward from 1956/57 ... ... | | | £314 1 10 |
| Interest on £250 War Loan ... ... ... | £8 15 0 | | |
| Interest—Edinburgh Savings Bank ... ... | 3 16 8 | | |
| | | 12 11 8 | |
| | | £326 13 6 | |
| Expenses ... ... ... ... ... ... ... | | 5 11 0 | |
| | | £321 2 6 | |
| Being— | | | |
| £250 3½% War Loan at cost ... ... | £203 12 0 | | |
| Edinburgh Savings Bank Account 312 | 117 10 6 | | |
| | | £321 2 6 | |

(Sgd.) RONALD T. HUNTER, C.A., Treasurer.

EDINBURGH, 16th May 1958.—I hereby certify that I have audited the Accounts of the Sir William Wright Smith Lectureship Fund for the Session 1957/58, and have found them correct. I have seen the Securities for the Invested Funds and found them in order.

(Sgd.) CHARLES A. SCOTT, C.A., Auditor.

The Honorary Secretary, Mr. P. S. Green, submitted the following Report from Council:

At the end of the Session membership of the Society stands at 361, composed of 37 Honorary Fellows, 262 Fellows, 31 Ordinary Members, 30 Lady Members and one Associate of Honour. The Society has lost 2 Fellows and 2 Members by resignation, and 5 Fellows and 2 Lady Members by death (of whom the most notable perhaps were Mrs. Menie Watt, Lady Russell, Dr. John Smith and Mr. Berwick, who was elected a Fellow in 1891). However, 29 Fellows and 11 Members and one Lady Member have been elected giving a net increase in membership of 22 Fellows and 9 Members.

Early in the year the Council co-opted as a member Mr. William Marshall, one of the University Botany Students and a Fellow of the Society. This representation of the student body on the Council has proved a most successful innovation and the Society is very grateful for all that Mr. Marshall has done to interest students in the Society, and to the students themselves for their increased loyalty and attendance at the meetings, thereby giving considerable encouragement to the Council and Office-bearers.

The Matthews Anniversary Volume Fund has increased steadily and now stands at £209. During the year, letters were sent to all Fellows and Members more than two years in arrears with their subscriptions and, with remission of overdue subscriptions granted up to the 1956/57 Session, they were urged to retake an active part in the Society. Also during the year a letter was sent by the President to all Fellows who compounded for life twenty years ago pointing out the differences between the composition fees and the costs of publications then and now. A number of very generous responses have followed from this letter and between £55 and £60 has been donated, although the sums were received after the books were closed for the present financial year.

Once again, as a Society, we should like to express our indebtedness to the Carnegie Trust for the Universities of Scotland for the generous grant of £100 made towards the cost of publication of the Society's *Transactions*. Nor would it be out of place here to express and put on record the Society's great indebtedness to Mr. Charles A. Scott, C.A., who has unfortunately

announced his resignation as Auditor of the Society's Accounts after many years.

Little need be said of the Society's programme for the past Session except that it has proved a very popular one and that attendances have been higher than for a number of years. This is most encouraging and it has been decided to follow the same principle of arranging the ordinary monthly meetings to be of wide appeal following a general theme with a few additional meetings on more specialised topics as well. The theme chosen for 1958-59 is "Plants and Man". Perhaps the most outstanding development within the Society this Session has been the formation of the Scottish Alpine Botanical Section—open to all Fellows and Members. The Section was founded as a new organisation within the Society rather than by resurrecting the Scottish Alpine Botanical Club. Mr. J. Grant Roger of the Nature Conservancy was elected Secretary of the Section. Two excursions have been arranged for summer; one for a full day took place last Saturday in the Breadalbane area and a most successful day it proved, and the other will take place in the area of the Black Mount. The Council is most anxious about the success of these meetings and as a large number of students and Fellows have notified their intention to attend it looks as if the Section will have a good start.

The other field meeting to be arranged by the Society is the Autumn Cryptogamic Foray to be held this year in the Edzell area on the 13th and 14th September.

A number of miscellaneous items warrant inclusion in this report. Firstly, Dr. Fletcher was appointed by the Council to represent the Society on the Council of the National Trust for Scotland in place of the late Sir William Wright Smith. The Society sent a cable of congratulation to the Botanical Society of Lund on the celebration of their centenary on the 29th March, and lastly, as many of you will recall, a very successful Conversazione was arranged in July last year to which members of the Plant Pathology Section of the British Mycological Society, who were holding meetings in Edinburgh, were invited. The Society put up an exhibit at the Edinburgh Show of the Scottish Rock Garden Club.

Considerable discussion has taken place within the Council about the expansion of the Society and its activities both within and outwith Edinburgh and meetings have been held both in

Glasgow and Aberdeen during the Session, the former a joint meeting with the Andersonian Naturalists of Glasgow.

Activity outside Edinburgh is one very important aspect of the Society's interests, and any encouragement or suggestions that Fellows or Members can make in this direction will be most warmly welcomed by the Council. Further expansion would, in fact, fit in with what has been a most successful year of increased vigour in all spheres of activity and interest within the Society.

TRANSACTIONS
OF THE
BOTANICAL SOCIETY OF EDINBURGH

SESSION CXXII

# Scottish Mountain Vegetation in Relation to Geology.

By Robert E. C. Ferreira
(Department of Botany, University of Aberdeen)*.

(Read 4th March 1958.)

## Introduction.

The mountain plants of Britain have always been a great attraction to botanists, and by the beginning of the nineteenth century our mountain flora had become fairly well known. Although the Scottish Highlands were first explored botanically towards the end of the eighteenth century, the Welsh hills had been botanised much earlier when Thomas Johnston made his famous expedition to North Wales in 1639. It was in 1772 that John Lightfoot made his visit to the Highlands, and he was probably the first botanist to ascend any of the higher Scottish hills; but in 1779 George Don began his well-known searches for mountain plants, which he continued for nearly thirty years, during which time he recorded several species new to the British Isles.

The earlier publications on Scottish botany, such as Lightfoot (1777) and MacGillivray (1855), were mainly floristic, and it was not until Robert Smith's pioneer work in 1900 on the vegetation of North Perthshire that the ecological aspects of the subject were first studied. Since then, and more particularly in the last ten years, there has been a number of publications describing

*This paper forms part of a thesis accepted by the University of Aberdeen for the degree of Ph.D.

mountain vegetation from an ecological standpoint. Notable amongst them are the series of papers on the ecology of the Cairngorm mountains by Watt and Jones (1946), Metcalfe (1950), Burges (1951) and Ingram (1958) as well as the accounts of other areas by Pearsall (1950), Poore (1955) and Poore and McVean (1957).

However, one of the first botanists to observe the relationship between certain mountain species and the rocks on which they grow was Dr. J. Gilchrist (1855), an amateur botanist who was familiar with the geology of the Highlands. He studied the plants of the Clova hills, such as *Viscaria alpina* and *Oxytropis campestris,* both of which are confined to habitats on single rock formations in this district, but unfortunately Gilchrist's results were never published in full. About the same time MacGillivray (1855) noted the contrast between the vegetation of the schists and granites in Upper Deeside, while MacNair (1898), in one of the classic papers of the subject, pointed out that a rich alpine flora in the Central Highlands of Scotland coincided with the outcrop of the Lawers Calcareous Schists (the "Sericite Schists"), which crop out from Knapdale in Argyllshire in the west to Caenlochan Glen in the east. Another well-known paper by Crampton (1911) describes the geology and vegetation of Caithness in considerable detail, relating them wherever possible. Matthews (1937) when discussing the Arctic-Alpine Element of the British flora, points out the marked effect on the vegetation of easily weathered rocks, rich in mineral salts, such as the Lawers Calcareous Schists, but he considers that the climatic factor is the most important in determining the distribution of this Element as a whole. A study by Price Evans (1945) of the vegetation of the Cader Idris district in relation to the bed-rock clearly demonstrates the effect of the calcareous lavas of this area on species distribution, while Hora (1947), dealing with the same area, discusses the pH range of certain "cliff-plants" in relation to the bed-rock. Pearsall (1950) also emphasises the importance of the rock and soil in the distribution of mountain plants, and Raven and Walters (1956) consider that one of the most important determining factors for the presence of a "rich flora" is the chemical content of the rock and soil. The work of Spence (1957, 1958) on the vegetation of the Unst Serpentine is also relevant because of the affinities of the climate of this island with

that of the more exposed tops of the N.W. Highlands.

Much of this ecological work has been carried out within relatively small areas, and little of it has been comparative. For the purposes of the present study four mountains were selected in order to show as far as possible variation in geology, topography and climate. These were Ben Hope and Ben Loyal in Sutherlandshire, Beinn Laoigh on the Perth-Argyll boundary and Glas Maol, including Caenlochan Glen in Angus, the several areas being representative of the Northern, Western and Eastern Highlands respectively.

Ben Hope (3,040 ft.), some fifteen miles N.W. of Altnaharra, is the most northerly mountain in the British Isles to exceed 3,000 ft. and it is within twelve miles of the north coast of Scotland. The great topographical feature of this mountain is the magnificent cliff, with a western exposure two miles long, which arises almost from sea-level in Strathmore. By contrast the southern and eastern slopes are smooth and gentle, although on the north-east side there are three fine corries, surrounded by considerable cliffs.

Ben Loyal (Beinn Laoghal), which lies only six miles to the east of Ben Hope, is completely different from the geological point of view. Its summit (2,504 ft.) is some five hundred feet lower than that of Ben Hope, but nevertheless its well-known craggy summits (tors) are extremely fine particularly when seen from the north side.

Beinn Laoigh (3,708 ft.), seven miles to the west of Dalmally, is somewhat encompassed by other mountains, so it is not easy to get a true impression of its considerable height. It exhibits steep cliffs more particularly on the north and east sides where several fine corries have developed.

Glas Maol (3,502 ft.) includes the Caenlochan Glen to which especial attention has been paid in this study; the glen itself is surrounded by precipitous cliffs which stand out in contrast to the gentle slopes of the southern and western sides of the mountain.

In addition to these four mountains it was found necessary to include certain other areas with noteworthy geology, when they had some bearing on the main investigation.

To carry out this investigation it was necessary first to obtain a relatively full knowledge of the geology of the several areas

with particular emphasis on the lithology of individual strata. It was decided therefore to survey the four mountains as accurately as possible, mapping only the ground lying above the drift-line, more attention being given to variation in lithology within the rock types than to the actual boundaries of the rocks themselves. This approach has proved most instructive for it has been found that there is often just as much variation in vegetation within any one geological formation as there is between two relatively contrasting formations. It will be shown later that this variation in the vegetation is often associated with varying lithology within a single geological formation.

Particular attention has been paid throughout this investigation to the distribution of carbonates because of their relatively high solubility within the rock where they occur, thus influencing the base status of many substrates. The three principal carbonate minerals, calcite ($CaCO_3$), dolomite ($CaCO_3.MgCO_3$) and magnesite ($MgCO_3$) though somewhat similar are by no means impossible to distinguish either by external characteristics, or by their response to dilute hydrochloric acid (20% HCl). If a rock contains either calcite or dolomite, it is referred to as calcareous or dolomitic respectively.

Only vegetation bearing a direct relation to the rock is considered in the present paper. It is not possible, however, to give a complete description of the vegetation of all four mountains, and only the general trends of the vegetation on each of the principal geological formations are indicated. A few selected examples showing this inter-relationship are described in greater detail.

For descriptive purposes the term *calcium-rich* soil has been adopted here to indicate a soil in which the amount of exchangeable Ca is greater than that of Mg, Na or K, as well as having a high level of the element *per se*. *Calcareous* soil is used only to denote a soil which contains free calcium carbonate, a condition which may not necessarily arise in a calcium-rich soil. A *basic* soil is used in its customary sense, as a general term to describe a soil of high base status, irrespective of whether Ca, Mg or Na is the dominant base.

Soils described as *acid* have a pH <5·0, whereas the reaction of a *mildly acid* soil lies within the pH range 5·0-6·0. Soils lying within the range pH 6·0-7·0 are here considered as *neutral,* while

the alkaline soil has a pH >7·0. Although such terms are not always defined within prescribed pH limits, it has been found useful to adopt this notation since it may help to reduce unnecessary ambiguity. *Flushes* are here considered as those areas within the influence of Ca-rich spring water; the term is not applied to ground in the vicinity of acid springs nor to the surrounds of Mg-rich springs. *Dry flushes* are likewise used in a more restricted sense than that adopted by Pearsall (1950), the term being applied only to those substrates which have been enriched by weathered particles of soft, calcareous rock.

Reference may now be made to terms that indicate the relationships of certain species to the reaction and base status of soils. The species associated with basic soils, more particularly with those that are Ca-rich, are known either as *calcicoles* or less frequently as *basiphiles*; however, both terms are used somewhat loosely and are sometimes considered to be synonymous. In a subsequent paper the author intends to show that it is possible to distinguish two fundamental groups among the species *confined* to basic mountain soils. The first group comprises species restricted to Ca-rich soils alone, while the second includes species that occur on both Ca- and Mg-rich soils. For present purposes, however, the term *basiphile* is used, rather than *calcicole,* to denote any species which is virtually confined, in the field, to neutral or alkaline soils.

There is a certain amount of evidence also to show that the terms *calcifuge* and *acidophile,* both of which are commonly employed to denote species characteristic of acid or mildly acid soils, could be complementary rather than synonymous, but in this paper only the latter term is used.

*Ben Hope.* The rich flora for which Ben Hope has long been famed is virtually confined to a comparatively narrow tract of ground on the lower crags of the great west escarpment; it is on these crags that both lowland and mountain basiphilous species are most abundant. Elsewhere on the mountain the vegetation is in general acidophilous and floristically poor, with the exception of certain sites associated with flushing in the N.E. Corrie and on the wind eroded habitats of the summit plateau.

That the majority of the arctic-alpine species of Ben Hope should be largely confined to crags between 1,500 and 1,700 ft. on the west escarpment alone appears at first somewhat surprising.

Careful survey shows, however, that their distribution is closely related to the band of hornblende schist which crops out across the cliff for a distance of about two miles. The remainder of the cliff both above and below these schists comprises the well-known acid Moine granulite that covers large areas of the Northern Highlands.

The hornblende schists can be traced as a continuous band across the entire west escarpment from the Allt na Caillich at the south end of the Leitir Mhuseil (the southern prolongation of Ben Hope) at about 700 ft. and thence they rise northwards until they reach 2,000 ft. beneath the summit of Ben Hope, where they turn north-eastwards and drop to only 1,400 ft. at the northern end of the cliff. The lithology of these schists varies both laterally and vertically within the outcrop, and it must suffice to say that they comprise a series of true hornblende schists, actinolite schists, epidotic schists and mylonites. All these rocks are relatively soft, with the exception of the last, and they are all calcareous to a greater or lesser extent throughout the main outcrop; however on Meallan Liath (1,962 ft.) to the east of Ben Hope the schists are non-calcareous. The mineral soils derived from the calcareous schists are neutral or occasionally alkaline in reaction, and on analysis they proved to be Ca-rich, though with a distinctly high magnesium content.

The vegetation of these dark, friable Ca-rich soils is often extremely luxuriant and frequently impressive, while the number of species comprising the vegetation is very large. The accompanying list, however, includes only those species which are exclusive to the band of hornblende schists, the total flora being exceedingly rich.*

| | |
|---|---|
| Angelica sylvestris | *Coeloglossum viride |
| *Anthyllis vulneraria | *Draba incana |
| Bellis perennis | *Dryas octopetala |
| Cardaminopsis petraea | *Galium pumilum |
| *Carex capillaris | *Juncus triglumis |
| *C. caryophyllea | †*Linum catharticum |
| *C. flacca | Orchis mascula |
| Cerastium alpinum | Plantago maritima |
| Circaea alpina | *Polygala vulgaris |
| Cirsium heterophyllum | †*Polygonum viviparum |

*Throughout this paper the nomenclature for vascular plants follows that of Clapham, Tutin and Warburg's *Flora of the British Isles.*

*Potentilla crantzii
Primula vulgaris
Rhinanthus spp.
*Rubus saxatilis
Salix lapponum
*S. reticulata
*Saxifraga aizoides
*S. hypnoides
†*S. oppositifolia
†*Thalictrum alpinum
*Tofieldia palustris
Trollius europaeus
Valeriana officinalis
Vicia sepium

Asplenium adiantum-nigrum
A. trichomanes
*A. viride
Botrychium lunaria
†*Cystopteris fragilis
*Equisetum hyemale
E. sylvaticum
Polystichum lobatum
†*P. lonchitis
†*Selaginella selaginoides

†*Campylium stellatum
*Cratoneuron commutatum
†*Ctenidium molluscum
*Distichium capillaceum
†*Ditrichum flexicaule
*Fissidens adianthoides
†*F. cristatus
*Orthothecium rufescens
†*Plagiochila asplenioides
*Preissia quadrata
†*Tortella tortuosa

*Basiphile species.
†Found also in the N.E. Corrie.

The basiphilous nature of the vegetation on these schists is apparent throughout the outcrop and species such as *Saxifraga aizoides, Saxifraga oppositifolia, Linum catharticum, Preissia quadrata, Ctenidium molluscum, Tortella tortuosa* and *Fissidens cristatus* are among the most abundant in suitable habitats on the formation.

In a fault gully at the southern end of the main escarpment, where the rocks are strongly calcareous, as they often are in the vicinity of faults, most of the basiphilous arctic-alpine species listed occur including *Salix reticulata,* first recorded for the county by Ferreira (1957). The willow grows on particularly unstable open ground subject to frequent erosion and this is apparently its only station on Ben Hope, where its habitat affords some evidence for the hypothesis that certain rare species can be correlated with open Ca-rich sites as suggested by Pigott and Walters (1954). The CaO levels ranged from 290 to 260 mg/100 gms.* in soils from this gully, and the MgO figures were in the region of 70 mg/100 gms. A further example of a rare species on Ben Hope occurring in an open base-rich habitat is *Equisetum hyemale* associated with *Saxifraga aizoides* and *Juncus triglumis* (see Ferreira, 1958).

*Figures for CaO and MgO are given as mg/100 gms. of air dried soil.

On the non-calcareous hornblende schists of Meallan Liath the situation is quite different, for although the mineral soil developed over these rocks is physically of the type formed on the main outcrop, and the altitude and aspect of both outcrops are likewise similar, their vegetation bears little comparison. Basiphilous species are quite absent from Meallan Liath, and an open community of *Thymus drucei* and *Festuca vivipara* has developed on the drier slopes. The springs arising from this outcrop are acid in reaction and only yield such species as Thyme and *Alchemilla alpina*. The acid nature of the soil (pH 4·7 was the highest figure obtained) indicates that although the hornblende schist is a basic metamorphic rock relatively rich in calcium and magnesium in the form of silicates, it has little influence on the base-content of the soil. These soils lend support to the view that the presence of calcium in the form of the carbonate in the parent rock is necessary to produce a neutral or alkaline Ca-rich soil.

On the granulite which forms the bulk of Ben Hope one finds a completely different set of plant communities from those on the hornblende schists. In general the rock is very hard and non-calcareous and comprises principally quartz and potash felspars. The vegetation associated with this rock is acidophilous and particularly monotonous, typical communities being those with such dominants as *Calluna, Vaccinium myrtillus, Trichophorum, Nardus* or *Carex bigelowii*. However, in the N.E. Corrie there are thin bands of calcareous granulite, and on soil or in crevices flushed by water arising from such rocks various basiphiles are to be found, for example *Saxifraga oppositifolia, Cystopteris fragilis* and *Polystichum lonchitis*. These isolated groups of basiphile species are especially conspicuous growing amongst the otherwise acidophilous vegetation of the corrie, which comprises principally *Vaccinium myrtillus, Nardus* and *Deschampsia caespitosa* communities. When these basiphilous plants were noted in the corrie the carbonate was not at first detected in the adjacent rocks owing to its deep-seated nature. Thus the occurrence of such a plant as the markedly basiphilous Holly Fern in granulite crevices was a source of considerable interest. On the other hand the dry calcareous granulites have no effect on the vegetation, thereby emphasising the importance of flushing by water in the case of very hard carbonate-containing rocks. The deep-seated nature

of the carbonate, which is a feature of the older and the coarser-grained *hard calcareous* rocks, results in the absence of basiphile mosses from the surface of the granulites. However, at one point in the corrie, where a recent fall has exposed fresh rock, the carbonate is detachable at the surface, and basiphilous mosses such as *Tortella tortuosa* are frequent.

The vegetation of the non-calcareous granulite is singularly monotonous and basiphiles are entirely absent with the exception of an interesting group of plants that grow in the wind-eroded habitats that are such a feature of the summits and higher crests of Ben Hope. Above 2,000 ft. O.D. these habitats are characterised by an open community of *Salix herbacea* and *Juncus trifidus* similar to that described by Poore and McVean (1957) in the Beinn Eighe district, but in the case of Ben Hope, there occur also cushions of *Cherleria sedoides, Silene acaulis* and *Armeria maritima*. Although these three species are more often associated with closed communities on basic soils, both *Silene acaulis* and *Armeria maritima* occur not infrequently in acid open habitats on the higher and more exposed summits of the Highlands. Nevertheless *Cherleria* is somewhat local in such habitats though Blake (1957) records it from quartzite débris on Foinaven (2,980 ft.) with the two other cushion-forming species and *Cardaminopsis petraea*. The deep, friable, micaceous soil of these highly exposed wind-eroded habitats is derived from the Moine granulites. This soil is always acid in reaction, the normal pH range being 4·4-4·7 and the CaO and MgO levels are low at 25·0 and 16·0 mg/100 gms. respectively. Although this habitat is primarily the result of climatic influence through frost-action and wind-erosion, its consideration is relevant in this study owing to the presence within the habitat of species usually associated with base-rich soils; the status of such species will be considered more fully later.

*Ben Loyal.* The geology of this hill is uniform in the sense that there is only one principal rock type, the Ben Loyal Syenite, an intrusive igneous rock, which covers some twelve square miles. Externally the syenite, an intermediate acid rock, is almost identical to a granite, the granitic jointing and weathering of the rock being responsible for the outward similarity. It comprises chiefly potash and sodium felspars, quartz being absent, thus distinguishing it from a granite. Read (1931) shows in a chemical

analysis of the syenite that $Na_2O$ and $K_2O$ figures are relatively high at 5·9% and 6·0% of the rock respectively, while the CaO and MgO levels are considerably lower.

The vegetation of Ben Loyal is similar to that of the non-calcareous granulites of Ben Hope. However, in three areas within the influence of springs arising from fissures in the rock, the flora is of a distinctly basiphilous nature. As in the granulite, it was found that the rock bordering on these fissures contained carbonate. Analysis of the soil from one of these flushes showed that the CaO and MgO levels were at 207 and 112 mg/100 gms. respectively, whereas an adjacent soil outwith the flushed area showed only 22·0 and 4·8 mg/100 gms. of CaO and MgO respectively. This demonstrates quite clearly the marked effect of calcite, and in this case some dolomite as well, on the calcium status of the soil. The fact that the $K_2O$ figure for the flushed soil is only 24·0 mg/100 gms. further emphasised the relative insolubility of silicates (the K is in the form of silicates only in the syenite) when one considers that $K_2O$ makes up nearly 6% of the parent rock.

However, owing to the hard rock, and also in some measure to the depth of the carbonate from the surface, dry flushing does not occur and the Ca-rich substrates are confined to the regions of the water originating from calcareous rock. Although these flushes are of very local occurrence on Ben Loyal, they serve as excellent examples of this habitat, which is not infrequent in the Northern Highlands. To emphasise the remarkable effect of such flushes on the floristic composition of an area a list of the species confined to their immediate vicinity on Ben Loyal is given below. All the plants listed cannot be considered strictly basiphilous, but the large majority of them, in the author's experience, occur only on substrates in the vicinity of calcareous rock:

Cochlearia alpina
Silene acaulis
Cerastium alpinum
Saxifraga oppositifolia
S. hypnoides
Rhinanthus borealis
Festuca rubra
Poa glauca
Cystopteris fragilis
Selaginella selaginoides
Ctenidium molluscum
Ditrichum flexicaule
Fissidens cristatus
Peltigera aphthora

*Beinn Laoigh.* The metamorphic rocks on this mountain belong to the Dalradian Series, and they constitute a succession

of contrasting rock types dipping generally southwards, and with the strike running from west to east. Of these the most important formations are the Ben Eagach Black Schists that crop out on the lower northern slopes, the Ben Lawers Calcareous Schists which are confined mainly to the middle part of these slopes and the Beinn Laoigh Garnetiferous Schists of the summit and southern slopes.

The mountain is renowned for its rich and varied flora (see Patton, 1923) and it can be stated at once that all the species for which it is especially noted are confined to habitats within the influence of the Lawers Schists. This is likewise the case for other hills including Ben Lawers itself, Meall nan Tarmachan and Ben Heasgarnich. On Beinn Laoigh the upper boundary of the schists reaches its highest point (c. 3,000 ft.) in Coire an Lochain, thence it turns eastwards and descends through Coire Gaothach into Coire Laoigh. The lower boundary some fourteen hundred feet below reaches its greatest altitude at the base of the precipitous Ciochan Crags. The rocks comprising this formation are virtually calcareous throughout and the two commonest rock-types within it are the soft sericite schist and a relatively hard impure limestone that is interbedded with the former. Dry flushing is prevalent on the schist in particular, and basiphilous communities develop frequently on the dry ledges. A comparison of this vegetation with that of the soft non-calcareous bands of the Laoigh Garnetiferous Schists shows that the flora of the Lawers Schists cannot be correlated with the softness of the rock alone. For, on the softer Laoigh Schists which with few exceptions are carbonate-free, a typical acidophilous flora has developed with a complete absence of basiphilous species, the most abundant plants being *Sedum roseum, Vaccinium myrtillus,* and *Alchemilla alpina.* It is the author's contention that had the Lawers Schists been likewise non-calcareous their flora would differ but little from that of the Laoigh Schists or any other carbonate-free schist elsewhere.

It is of particular interest that a small band of Laoigh Garnetiferous Schist which proves to be calcareous crops out on the highly exposed col between the two tops of the mountain and yields *Saxifraga oppositifolia* and *Polygonum viviparum.* It is significant that these common basiphilous species are absent from the somewhat similar wind-eroded habitats of Ben Hope, where

other reputed basiphiles occur not infrequently (e.g. *Cherleria sedoides*), however the presence here of the Saxifrage on an exposed Ca-rich soil shows that it is not exposure of habitat that is restricting its distribution on the summit of Ben Hope, but rather the calcium status of the soil. From these facts it may be contended that the three cushion-forming basiphile species of the plateau of Ben Hope, i.e. *Cherleria, Armeria* and *Silene acaulis,* are tolerant of open base-deficient habitats whereas plants such as the Purple Saxifrage are intolerant of any acid habitat.

The Ben Eagach Black Schists are harder than those of the two formations already referred to and only become calcareous near the boundary with the Lawers Schists. They have little influence on the vegetation and any Ca-rich soils developed over them have chiefly been flushed by water originating from the Lawers Schists.

In Glen Choninish, to the east of Beinn Laoigh, there are several lead tips at about 1,200 ft. on the Black Schist formation. Much of the lead tip débris is nearly barren with the exception of scattered tufts of *Agrostis* spp. and a few plants of *Cerastium vulgatum.* However, on one particular tip the flora is comparatively rich, including such species as *Silene acaulis, Saxifraga aizoides, S. oppositifolia, Festuca rubra, Tortella tortuosa* and *Preissia quadrata.* On investigation it was found that this tip alone contains calcareous schist within the débris. A large amount of galena is present on each tip, and the lead content of these soils must considerably exceed the toxicity level; however, on the calcareous tip the amount of available Pb will be relatively small. The pH of both tips is similar (c. 6·4), thus it is likely that the calcium ion is reducing the uptake of Pb rather than the soil reaction. Experimental work carried out by the author supports this view, as does work done by Wilkins (1957).

Of the other formations cropping out on Beinn Laoigh the epidiorite in particular deserves mention. It forms a series of conspicuous crags that rise eastwards across the northern slopes of the mountain. The epidiorite, which is exceedingly hard and resistant to weathering is a basic metamorphic rock that is quite strongly calcareous throughout. But, as in the case of the Moine granulite and the Ben Loyal Syenite, Ca-rich substrates are developed only in the vicinity of springs arising from fissures in the calcareous epidiorite, that is only in flushes. In such habitats,

*Saxifraga aizoides, Carex capillaris* and several basiphilous mosses are frequent, but on the drier ledges the vegetation is markedly acidophilous.

The above examples demonstrate not only the great importance of calcite-bearing rocks on the distribution of basiphilous species, but also the necessity for such rocks to be relatively soft to make possible a floristically rich basiphilous vegetation.

*Glas Maol* (*Caenlochan Glen*). As on Beinn Laoigh rocks of the Dalradian metamorphic series cover large areas of the mountain, and in certain cases the same stratigraphical divisions are common to both mountains, as for example the Lawers Calcareous Schists and the Ben Eagach Black Schists, both of which crop out within Caenlochan Glen. The former occur only in a small area on the north side of the glen, where they are clearly exposed on a series of crags facing south-west. These crags, which are a little over 2,000 ft. O.D., yield a most impressive flora which is the richest with respect to mountain basiphile species that the author has yet encountered in the Highlands (Matthews, 1940: Roger, 1941, 1954). There seems little doubt that the profusion of species is due entirely to the presence of a bedrock that is both highly calcareous and extremely soft. The schist is most probably the softest of the metamorphic rocks of the Highlands, resulting in widespread dry flushing on the formation. Soils formed in this way contain an unusually high Ca content for mountain habitats and most of them are strongly calcareous. Their pH may be as high as 7·6, and on analysis a CaO figure of 1,006 mg/100 gms. was obtained in a typical dry-flushed soil. The figures for MgO, $Na_2O$, $K_2O$ and $P_2O_5$ are all at low levels and they afford little evidence of a high content of mineral nutrients in the soils derived from the Lawers Schists, as is often considered to be the case. Indeed, due to the unusually high Ca levels the other major bases are likely to be relatively less available than they are in a typical acid soil.

On the drier ledges, communities dominated by *Dryas octopetala* occur frequently, and on certain of the dry slopes a *Carex rupestris* community has developed. On slightly moist ledges a community characterised by *Silene acaulis, Saxifraga oppositifolia* and *Alchemilla alpina* is widespread; and among the associated species are *Potentilla crantzii* and *Veronica fruticans*, the latter being unusually frequent in this locality. Distinctly

moist ledges and slopes exhibit communities in which either *Salix reticulata* or *Carex capillaris* is dominant, with *Thalictrum alpinum, Saxifraga aizoides* and *Polygonum viviparum* as abundant associates. On very wet and almost vertical rock faces a hanging mat of vegetation becomes characteristic, comprising principally the intertwined stems and rhizomes of *Saxifraga aizoides, Festuca rubra* and *Campylium stellatum.* This community is entirely confined to soft calcareous rocks and it is not uncommon therefore on the Lawers Schists outcrop, occurring also quite frequently on the Ciochan Crags of Beinn Laoigh.

It is of interest that these crags and slopes face to the south-west thereby being exposed to the full afternoon sun in summer and even in winter the site is subject to an hour or two of sun on clear days. Snow cover is slight in winter and the crags are indeed sometimes free from snow when adjacent slopes with an eastern aspect may carry drifted snow to a depth of three or four feet.

At the head of the glen in the south-east corner, there is an outcrop of greatly indurated calcareous schist which, however, is not usually considered as belonging to the Lawers Schist series. The associated flora is particularly rich with respect to the total number of species, but in general basiphilous species are present in smaller quantity than on the Lawers Schists habitats on the opposite side of the glen. Nevertheless, certain bands of the rock are sufficiently soft to encourage dry flushing, and in these habitats there occur rarities such as *Thlaspi alpestre, Gentiana nivalis* and *Salix lanata,* all of which are basiphiles.

The Ben Eagach Black Schists or the graphitic schists crop out in a large area at the head of the glen, to the west of the Glas Allt. In the Eastern Highlands this formation is represented by a soft easily weathered dark graphite schist, which appears in this district to be non-calcareous throughout. Due to the proximity of this formation to the Lawers Schists, especially in the gully through which the Glas Allt flows, a comparison of their vegetation proved of considerable interest. The vegetation on the graphitic schists bears no relation to that on the Lawers Schists, for the former is entirely acidophilous and comprises very few species. This is particularly significant because the graphitic schist is one of the softest of the acid metamorphic rocks in Scotland, and this fact again emphasises the point that a soft

non-calcareous rock has very little influence on mountain vegetation. The CaO level in one of these soils at 30 mg/100 gms. is similar to that of a granulite soil of Ben Hope, and the pH range is 4·2-4·4. Open habitats are developed on this formation due to gravitational erosion, although species such as *Silene acaulis* are absent from these habitats owing to their extreme instability.

In acid springs originating from the graphitic schists on the upper slopes of the glen, both *Phleum commutatum* and *Alopecurus alpinus* occur, but the latter is rare.

Of the other formations found in Caenlochan, the quartz-porphyry merits some comment. It is a hard fine-grained acid igneous rock that is mildly calcareous; but as in the case of other hard calcareous rocks already discussed only flushing by water influences the floristic composition of the vegetation. Where flushing occurs basiphile species such as *Polystichum lonchitis* and *Cystopteris fragilis* are not infrequent in the moist crevices of the rock.

These selected examples from Caenlochan show that the general effect of the bedrock on the vegetation follows a similar pattern to that observed on Beinn Laoigh, and they again demonstrate the importance of a soft calcareous rock for the development of a rich alpine flora.

*Other areas.* The effect of basic metamorphic rocks on vegetation has already been considered in connection with the hornblende schists of Ben Hope, but little reference has so far been made to basic igneous rocks, since they are virtually absent from the areas so far considered. The diorites of the Eastern Highlands are an excellent example of this type; they have a relatively low $SiO_2$ content and high CaO level, although the Ca is normally in the form of silicates, chiefly plagioclase felspars such as labradorite. It has been observed that whenever these rocks are non-calcareous their vegetation is acidophilous and not unlike that of a granite. However, in two of these diorites, those of Corrie Kander in Aberdeenshire and Glen Doll in Angus, areas of slightly calcareous rock have been detected. Spring-water arising from this rock in Corrie Kander was found to have a Ca level of 18·75 mg/L, while adjacent springs coming from non-calcareous diorite yielded only 1·5-4·0 mg/L Ca. These differences are reflected in

the vegetation, the flora of the Ca-rich locality being dominated by the markedly basiphilous moss *Cratoneuron commutatum* while the other locality has an abundance of *Montia fontana* and *Philonotis fontana,* both of which are characteristic of acid springs.

A study of a large number of basic igneous rocks throughout the Highlands leads very definitely to the view that in the non-calcareous rocks of this type the calcium silicates, if soluble at all, yield Ca ions to percolating water only at such a slow rate that the water emerging from the rock is still too low in calcium to produce a calcium flush. On the other hand in areas where there is a considerable depth of basic rock, as in the gabbro of the Cuillin, it is possible that water penetrating through the mountain before emerging near the base may have become slightly enriched in Ca from the silicates. Nevertheless, when Ca-rich water arises from basic rocks it owes its origin normally to calcium carbonate and not to calcium silicates.

## DISCUSSION.

One of the most important single effects of the geology of a mountain in relation to its vegetation is the formation of a variety of plant habitats. These are determined largely by the physical properties of the underlying bedrock and its rate of erosion, an important feature being the capacity of a rock to form crevices and ledges. This is an important factor affecting the distribution of a mountain flora and its occurrence on relatively stable level habitats, often outwith the influence of grazing.

The drainage on many mountains is strongly influenced by the nature of the underlying rock where jointing in igneous rocks and the direction of dip of metamorphic rocks can divert the course of drainage water. Such diversion has been noted on both Ben Hope and Beinn Laoigh, and by Pearsall (1950) on Ben Wyvis.

Throughout this paper emphasis has been placed on the marked effect of Ca-rich substrates on the composition of mountain vegetation, and with regard to this vegetation one of the most important chemical properties of any rock is the relative solubility of the calcium minerals within it. Of these various calcium minerals in the rocks of the Highlands the author considers that only calcite and dolomite are sufficiently soluble to

be of any significance in the formation of Ca-rich soils. It follows thus that in the Scottish Highlands Ca-rich substrates are derived only from calcareous or dolomitic rocks and basic igneous and metamorphic rocks that are neither calcareous nor dolomitic only produce substrates with low calcium content.

The significance of wet and dry flushing by hard and soft calcareous rocks respectively has been discussed and exemplified, and the importance of these flushed habitats to the distribution of the mountain flora has been demonstrated. From an extensive survey of this flora, it is concluded that all the floristically rich areas of the Highlands are associated with outcrops of soft calcareous rock. The flora itself is not inconsiderable and in the list of Scottish mountain plants given below, the species are arranged provisionally in three groups according to their edaphic preferences in the field.

Group I comprises species which appear to be distinctly basiphilous, some being more strongly so than others. They have all been noted to occur on substrates within the influence of or in the immediate vicinity of calcareous rock. None of them has been found on acid soils outwith this influence, although some do occur on certain Mg- or Na-rich soils.

It is appreciated that not all the species of Group I would be accepted as basiphiles by every botanist familiar with mountain vegetation, but in this connection it may be pointed out that in some instances the presence of calcium carbonate has been established only after a prolonged search over rocks which might otherwise have been deemed non-calcareous. Watson (1918) points out that where basiphilous mosses grow on substrates apparently outwith the influence of calcareous rock, subsequent investigation disproves this assumption.

It is of interest that some of the species that occur only near calcareous rocks in mountain habitats are likewise confined to Ca-rich substrates in the few stations where they grow at low altitudes, such as *Saxifraga hypnoides* on the coast of N.E. Scotland both on calcareous dune and scree (Ferreira & Roger, 1957). Other examples are *Saxifraga oppositifolia* and *Dryas octopetala*.

Group II is subdivided and IIa includes species which normally grow in the vicinity of calcareous rock, but occur also in certain stable acid habitats where plant cover is almost

negligible. The three cushion-forming species of the summit plateau of Ben Hope are included in this category. It is suggested that such species can tolerate acid soils only when root competition is apparently not severe.

In Group IIb there are certain species of wet habitats, e.g. *Saxifraga rivularis*, that most frequently grow on substrates within the influence of a calcareous rock but occasionally have been observed in stations where it has not been possible to establish the presence of calcite-bearing rocks in their vicinity.

Finally, in Group III are included both acidophilous species and those that appear to be indifferent to soil reaction.

## GROUP I.

(b) Agropyron donianum
(a) Arabis alpina
(b) Arenaria norvegica
(a) Astralagus alpinus
(a) Bartsia alpina
(a) Carex atrata
(a) C. atrofusca
(a) C. capillaris (E)
(a) C. microglochin
(a) C. norvegica
(a) C. rupestris (E)
(b) C. saxatilis
(a) Cerastium alpinum
(b) Cochlearia micacea
(a) Draba incana
(a) Dryas octopetala
(b) Erigeron borealis
(a) Gentiana nivalis
(c) Juncus alpinus
(a) J. biglumis
(a) J. castaneus
(a) J. triglumis
(a) Kobresia simpliciuscula
(b) Minuartia rubella
(a) Minuartia verna
(a) Myosotis alpestris
(a) Oxytropis campestris
(d) O. halleri
(a) Poa glauca
(a) Polygonum viviparum
(a) Potentilla crantzii
(b) Rhinanthus borealis
(c) Rubus saxatilis
(b) Sagina intermedia
(a) Salix arbuscula
(b) S. lanata
(a) S. myrsinites
(a) S. reticulata (E)
(a) Saussaurea alpina
(a) Saxifraga aizoides (E)
(a) S. cernua
(c) S. hypnoides
(a) S. nivalis
(a) S. oppositifolia (E)
(d) Thlaspi alpestre
(a) Tofieldia pusilla
(a) Veronica fruticans

Asplenium viride (E)
Cystopteris fragilis
C. montana
Equisetum hyemale
Equisetum variegatum
Polystichum lonchitis
Woodsia alpina
W. ilvensis

## GROUP IIa.

Armeria maritima
(a) Cardaminopsis petraea
(d) Cherleria sedoides
(b) Draba rupestris
(a) Silene acaulis

GROUP IIb.

(a) Poa alpina
(a) Sagina saginoides
(a) Salix lapponum
(b) Saxifraga rivularis
(a) Thalictrum alpinum
Selaginella selaginoides

GROUP III.

(a) Alchemilla alpina
(b) Alopecurus alpinus
(c) Antennaria dioica
(a) Arctostaphyllos uva-ursi
(a) Arctous alpina
(b) Artemesia norvegica
(a) Betula nana
(a) Carex bigelowii
(a) C. lachenalii
(c) C. pauciflora
(b) C. rariflora (E)
(a) C. vaginata
(a) Cerastium cerastioides
(b) C. edmonstonii
(b) Chamaepericlymenum suecicum
(a) Cicerbita alpina
(b) Deschampsia alpina
(b) Diapensia lapponica
(a) Empetrum spp.
(a) Epilobium alsinifolium
(a) E. anagallidifolium
(a) Gnaphalium norvegicum
(a) G. supinum
(a) Juncus trifidus
(a) Loiseleuria procumbens
(b) Luzula arcuata
(a) L. spicata
(a) Oxyria digyna
(a) Phleum commutatum
(a) Phyllodoce coerulea
(b) Poa flexuosa
(b) Rubus chamaemorus
(a) Salix herbacea (E)
(a) Saxifraga stellaris
(a) Sedum rosea
(a) Sibbaldia procumbens
(a) Vaccinium uliginosum
(a) V. vitis idaea
(a) Veronica alpina
(a) V. serpyllifolia ssp. humifusa (E)

Athyrium alpestre
Cryptogramma crispa
Lycopodium alpinum
Lycopodium annotinum
L. clavatum
L. selago

(E) Confirmed by experimental evidence
(a) Arctic-Alpine Element
(b) Arctic-Subarctic Element
(c) Northern Montane Element
(d) Alpine Element
} of Matthews (1955)

In a paper by Matthews (1937) on the geographical relationships of the British flora, the influence of climate on the distribution of arctic-alpine species is stressed, the Eastern being regarded as having a more arctic climate than the Western Highlands. The work recorded in this paper emphasises the importance of edaphic conditions and these may well modify the effect of climate. Within the Scottish Highlands the occurrence of a large number of mountain species is limited by the distribution of calcareous rock. Therefore, although the significance of basic habitats to the mountain flora has not been wholly overlooked,

perhaps the fundamental importance to Scottish mountain vegetation of the presence of calcium carbonate in a rock and the resulting Ca-rich substrates has not been fully appreciated.

SUMMARY.

The inter-relationships of the geology and vegetation of four Scottish mountains considered representative of the Highlands are described and discussed.

Evidence is presented to show that virtually all Ca-rich substrates in the Highlands are ultimately derived from calcareous or dolomitic rocks. Basic rocks containing a high level of Ca in the form of relatively insoluble silicates, and where $CaCO_3$ is absent, have little influence on the calcium status of substrates derived from them. It is shown that wet and dry flushes are associated with hard and soft calcareous rocks respectively.

The marked effect of the Ca-rich substrates on the distribution of the mountain flora is emphasised and the strong correlation between floristically rich vegetation and soft calcareous rock is pointed out.

A list of basiphilous mountain species confined to the immediate vicinity of calcareous rock in the Highlands is given, together with further lists of species more tolerant of acid conditions.

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# Flora of the Isle of Jura.

## I. Flowering Plants and Ferns.

By R. B. Knox
(Edinburgh University Biological Society).

(Received, 6th October, 1958.)

The following list represents the first attempt to compile a systematic list of the flora of this easily accessible but almost unknown island. It is based on records and specimens collected on the Edinburgh University Biological Society's Expedition to North Jura in June and July, 1957. This visit was made possible by the kind co-operation of the landowner, Mr. R. G. Fletcher, Ardlussa.

In comparison with many of the other islands of the Inner Hebrides, Jura has long been neglected by botanists. This neglect is in part the result of a natural reluctance to study the rather limited flora, mainly of bog and woodland which have developed on acid quartzite, a rock which covers nearly the whole of the northern end of the island.

All the specimens collected on the Expedition have been deposited in the Herbarium at the Royal Botanic Garden, Edinburgh. In the list, arrangement and nomenclature are based on: Dandy, J. E., *List of British Vascular Plants,* London, 1958.

*: before the generic name, indicates the species is a new record for V.-C. 102, S. Ebudes.

!: after the specific name indicates a specimen was collected.

a: species found in National Grid Square: 16/6—8—.

b: species found in National Grid Square: 16/6—9—.

c: species found in National Grid Square: 16/7—9—.

d: species found in National Grid Square: 16/5—8—.

Equisetum fluviatile. a, b. E. arvense. a, c.

Osmunda regalis. !, a. Rare, riverside, near graveyard, Inverlussa.

Hymenophyllum wilsonii. c.

Pteridium aquilinum. a, b, c. Common, especially in fields which were formerly cultivated, and are now sheep-grazed. These stand out on the hillsides as large rectangular patches of bracken.

Blechnum spicant. a, b, c.

Phyllitis scolopendrium. a. Crevices in wall, Ardlussa.
Asplenium marinum. !, b, c. A. trichomanes. !, a, c.
Dryopteris filix-mas. !, a, c. D. dilatata. !, a, c.
Polypodium vulgare. a.
Juniperus communis ssp. nana. !, a, c. Collected on Cnoc Na Glaic Moire, alt. 250′. Moorland—*Calluna* bog. Grid Ref. 16/659901.
Caltha palustris. a, b, c.
Ranunculus acris. !, c. R. repens. a, c. R. flammula ssp. flammula. !, a, c.
Nymphaea alba. b.
*Corydalis claviculata. b. In valley bog, Glengarrisdale. Grid Ref. 16/646967. Determined by R. B. Knox and J. G. Urquhart.
*C. lutea. c. On old wall, near Kinuachdrach. Grid Ref. 16/70-98-. Det. D. Dresser.
Cochlearia officinalis. !, a, b, d.
Cardamine flexuosa. b.
Viola palustris. a, b.
Polygala vulgaris. !, b. P. serpyllifolia. !, a, b, c.
Hypericum androsaemum. !, a, b. On shaded crevices of maritime cliffs north of Glengarrisdale. Also in roadside meadow at Ardlussa. H. pulchrum. a, c.
*Helianthemum chamaecistus. b. Rare. Hillside, near calcareous outcrop, Glen Trosdale. Grid Ref. 16/683999. Det. R. B. Knox. Coll. F. Oldfield and N. Maclean.
Silene maritima. c.
Lychnis flos-cuculi. a, b, c.
Cerastium glomeratum. !, c.
Stellaria media. b, c.
Sagina procumbens. !, c.
Honkenya peploides. a.
Spergula arvensis. a.
Spergularia media. !, d. Crevices on flat rocky shore, Upper Loch Tarbert. S. marina. !, d. Growing in same habitat as *S. media*.
Montia fontana ssp. fontana. (Det. S. M. Walters.) !, a, d. Habitat on Loch Tarbert as *Spergularia media*.
Atriplex glabriuscula. !, b.
Linum catharticum. b.
Geranium robertianum. b. Rocky shore, south of Glengarrisdale.
Oxalis acetosella. a, b, c.
Acer pseudoplatanus. b.
Ulex europaeus. a, b, c.
Sarothamnus scoparius. b. Rare in Glen Trosdale, with *Helianthemum* and *Fragaria*, calcareous hillside.
Trifolium pratense. !, a, c. T. campestre. c. T. repens. !, a.
Lotus corniculatus. a, b.
Vicia cracca. a.
Lathyrus pratensis. !, a. *L. sylvestris. c. Birch woodland, near Kinuachdrach. Grid. Ref. 16/70-98. Det. D. Dresser.

Filipendula ulmaria. a, b.
Rubus idaeus. !, a.
R. fruticosus. s.l.: R. nemoralis P. J. Muell. !, a. R. polyanthemus Lindeb. !, a. (Det. E. S. Edees.)
Potentilla palustris. !, a. Riverside, Inverlussa, in *Phragmites* swamp. P. anserina. b. P. erecta. a, b, c.
Fragaria vesca. b. Rare, only at Glen Trosdale, with *Helianthemum*, q.v.
Geum rivale. !, c.
Rosa pimpinellifolia. a.
Crataegus monogyna. b.
Sorbus aucuparia. a, b, c.
Sedum rosea. b, c. Maritime cliffs. S. anglicum. a, b, c.
Chrysosplenium oppositifolium. b.
Parnassia palustris. b.
Drosera rotundifolia. !, a, b, c. D. anglica. !, a.
Lythrum salicaria. a.
Epilobium montanum. a, b, c.
Fuchsia magellanica. a. Hedgerow plant at Ardlussa.
Circaea lutetiana. a, c.
Myriophyllum alterniflorum. !, b.
Hippuris vulgaris. c.
Callitriche stagnalis. !, a, c.
Hedera helix. b, c.
Hydrocotyle vulgaris. b, c.
Conopodium majus. !, a, c.
Oenanthe crocata. !, a.
Ligusticum scoticum. !, a.
Heracleum sphondylium. !, a.
Mercurialis perennis. b.
Polygonum aviculare. *s.l.* c. P. amphibium. !, a, b. P. persicaria. c.
*P. campanulatum Hook f. var. fulvidum Hook f. ! Rare alien. Grows only in small clearing in coniferous woodland, near Ardlussa. Grid Ref. 16/652881. Det. R. B. Knox. Introduced in 1930s. Colony has since spread and swamped surrounding vegetation.
Rumex acetosella. *s.l.* !, a, b. R. acetosa. !, a, b. R. crispus × obtusifolius. (Det. J. E. Lousley.) !, a.
Urtica dioica. a, b. Common, especially in ruins of cottages.
Myrica gale. a, b.
Betula pendula. !, a, c.
Alnus glutinosa. !, a, b.
Corylus avellana. a, b, c.
Castanea sativa. a.
Quercus robur. !, a. A dwarfed form, growing on exposed plateau above Inverlussa.
Populus tremula. c.
Salix aurita. !, a, c. S. cinerea × aurita. !, a.
Calluna vulgaris. a, b. c.

Erica tetralix. a, b, c. E. cinerea. !, a, b, c.
Vaccinium myrtillus. !, a, b, c.
Empetrum nigrum. !, b, c.
Armeria maritima. a, b, c.
Primula vulgaris. a, b, c.
Lysimachia nemorum. a, c.
Anagallis tenella. !, a, b. Rare, in small clumps on *Sphagnum* hummocks in bogs.
Glaux maritima. a.
Samolus valerandi. !, d. Rare, flat rocky shore, Upper Loch Tarbert.
Menyanthes trifoliata. b.
Myosotis caespitosa. !, b.
Scrophularia nodosa. a, b.
Digitalis purpurea. a.
Veronica chamaedrys. a.
Pedicularis palustris. b. P. sylvatica. !, a.
Rhinanthus minor. a, b, c.
Melampyrum pratense. !, a.
Euphrasia brevipila Burnat & Gremli. !, a. (Det. E. F. Warburg).
Pinguicula lusitanica. !, a, b. Uncommon, small clumps in bogs. P. vulgaris. !, a, b, c.
Thymus drucei. b.
Prunella vulgaris. !, a, b.
Scutellaria galericulata. b.
Teucrium scorodonia. a, b.
Ajuga reptans. !, a, c.
Plantago major. a, c. P. lanceolata. !, a, b, c. P. maritima. !, a, b. Found inland on shore of Loch a' Gheoidh.
Campanula rotundifolia. a. Rare, only found on roadside at Inverlussa.
Lobelia dortmanna. !, b.
*Cruciata chersonensis (Willd.) Ehrend. Hedgerows near Inverlussa.
Galium saxatile. !, a. G. palustre ssp. palustre. !, a. G. aparine. a, b, c. Common, especially amongst rocks on the shore.
Sambucus nigra. a.
Lonicera periclymenum. a, b. Remarkably common, especially in birch woodland on East coast.
Valeriana officinalis. a. Riverside swamp, Inverlussa.
Succisa pratensis. a, b.
Senecio jacobaea. b. S. aquaticus. !, a, c. S. vulgaris. a.
Solidago virgaurea. !, b, c.
Bellis perennis. a, b, c. Uncommon, waste ground, and grazed turf.
Tripleurospermum maritimum ssp. maritimum. a, c. ssp. inodorum. a, c.
Chrysanthemum segetum. a, c.
Arctium lappa. a, b.
Carduus acanthoides. a, b.
Cirsium palustre. c.
Centaurea nigra. !, a.
Lapsana communis. !, a.

Hypochaeris radicata. !, a, b, c. Common, dry hillsides, cliffs, and maritime slopes.

Leontodon autumnalis. !, a, b, c. Common in wet pasture, and maritime rock crevices.

Sonchus oleraceus. b.

Hieracium vulgatum. !, b. (Det. P. D. Sell). H. pilosella. !, b.

Crepis paludosa. !, a, b.

Taraxacum officinale. a, b.

Triglochin palustris. !, a, b. T. maritima. !, b.

Zostera marina. !, a. Grows offshore at Eilean A' Bhorra, near Lussagiven, and at Eilean Buidhe Mhor, north of Ardlussa. Rare.

Potamogeton natans. !, b. Submerged in Loch a' Gheoidh. P. polygonifolius. !, b. Common, ditches in bogs.

Narthecium ossifragum. !, a, b.

Endymion non-scriptus. a, b, c.

Juncus squarrosus. !, a, c. J. effusus. !, a, b, c. J. conglomeratus. !, a, c. J. bulbosus. !, a, b. J. acutiflorus. !, a, b. J. articulatus. !, a, b.

Luzula sylvatica. a, b. L. campestris. a, b, c. L. multiflora. !, a, b. L. congesta. !, a.

Iris pseudacorus. a, b, c.

Gymnadenia conopsea. a.

Dactylorchis fuchsii ssp. fuchsii. !, a. Rare, meadow near jetty, Ardlussa. D. maculata ssp. ericetorum. !, a, b, c.

Lemna minor. a.

Sparganium erectum ssp. erectum. !, a. Riverside swamp, Inverlussa,

Eriophorum angustifolium. !, a, b, c. E. vaginatum. !, a, b, c.

Scirpus caespitosus. !, a, b, c. S. maritimus. !, a. Ardlussa Bay, uncommon. S. lacustris. !, b.

Eleocharis multicaulis. !, b.

Rhynchospora alba Vahl. !, a.

Carex binervis. !, a. C. demissa. !, a, b. C. panicea. !, a, b, c. C. nigra. !, a, b, c. C. echinata. !, b.

Phragmites communis. a, c.

Molinia caerulea. !, a, b, c.

Sieglingia decumbens. !, b.

Festuca pratensis. !, a. F. rubra. a, b, c. F. ovina. a, b, c. F. tenuifolia. b.

Lolium perenne. a, b. L. multiflorum. a.

*Vulpia myuros. !, a, b. Near cottage, Glengarrisdale, and at roadside between Ardlussa and Lealt. Det. R. B. Knox.

Poa annua. b. *P. nemoralis. b. Edge of valley bog, Glengarrisdale. Det. R. B. Knox.

Catabrosa aquatica. a.

Dactylis glomerata. a, c.

Cynosurus cristatus. a, b, c.

Bromus mollis agg. a.

Arrhenatherum elatius. !, a, b.

Holcus lanatus. !, a, b. H. mollis. a.

Deschampsia caespitosa. !, a. D. flexuosa. !, a, b, c.

AIRA PRAECOX. a, b.

AGROSTIS CANINA ssp. CANINA. !, a. (Det. B. L. Burtt). A. CANINA ssp. MONTANA. !, a. A. TENUIS. !, b. A. GIGANTEA. !, a. Rocky crevice, Eilean Buidhe Mhor. A. STOLONIFERA. !, a.

ANTHOXANTHUM ODORATUM. !, a, b, c.

NARDUS STRICTA. !, a, b, c.

# The Mountain Plants of the Moffat Hills.

By Derek A. Ratcliffe
(The Nature Conservancy, Edinburgh).

(Received, 2nd November, 1958.)

## Introduction.

More notable for mountain plants than any other part of the Southern Uplands is the stretch of hill country lying between Moffat and Tweedsmuir. The area is defined more exactly as the massif drained by the Moffat and Annan Waters, Meggat Water and the headstreams of the Tweed: it thus spreads into the counties of Dumfries, Selkirk and Peebles, whose marches follow the main watersheds. Victorian botanists worked the area well, so that by the end of the nineteenth century Scott-Elliott (1896) was able to give fairly complete information on the distribution of the rarer plants. In particular, a Moffat botanist, J. T. Johnstone, made several interesting finds. Less attention seems to have been paid in succeeding years, but the recent discovery of three noteworthy species would indicate that the possibilities of the district are not yet exhausted. This account deals mainly with the relict montane and sub-montane plants which form the distinctive element in the flora of the Moffat Hills.

## Description of the Area.

A broad ridge with several summits rising above 2,500 ft. forms a backbone to the Moffat Hills and has a south-west—north-east axis. The south-east side of this range, drained by Moffat Water, has been heavily glaciated and three deeply-cut, parallel dales of Black's Hope, Carrifran and the Tail branch from the main valley. It is the craggy sides of these glens which harbour most of the mountain plants of the area. The last of the trio is famous as a hanging valley and a scenic feature of more popular appeal, with the stream which flows from the high-lying Loch Skene plunging into a great chasm as the Grey Mare's Tail. Several other streams in the Dumfriesshire part of the area have cut deep, rocky ravines along their lower courses. The broad watersheds above are often peaty and rise gradually into extensive plateaux, as on Hart Fell (2,651 ft.), White Coomb (2,696 ft.)

and Lochcraig Head (2,625 ft.). This mature type of upland topography prevails over the whole northern part of the Moffat Hills, with rounded spurs and summits descending by steep, smooth slopes into winding valleys. The Selkirkshire portion has moorland country typical of the Borders, and the Peeblesshire section is similar, but with a few crags, mainly on Talla Water.

These hills are composed almost entirely of Silurian greywackes and shales, which, from their relative ease of weathering, often yield fairly good soils, but do not readily give rise to cliffs. The softer shales, in particular, break down into basic soils, and there are frequent occurrences of crushed zones of rock containing large amounts of solid calcite. These are very susceptible to erosion by streams and so their tracks are commonly marked by ravines. Though much of the outcrop is acidic, patches of lime-bearing rock occur in all the main crag ranges, and calcareous flushes are frequent wherever water drains from the richer materials. Skeletal brown-earths of moderate base-status are widespread, but podsolic and acidic peat types predominate. The gentler slopes of the valley floors are mostly drift-covered, and there are well-developed moraine systems, notably in the valley of the Tail Burn.

The district is much less oceanic than Galloway to the west, with a drier climate and much lower winter temperatures. Average annual rainfall on the highest ground is over 80 ins. and probably does not fall below 50 ins. within any part of the Moffat Hills. Precipitation is only slightly higher, but atmospheric humidity consistently much greater, over the Galloway Hills. Together with the high ground immediately to the north, the Moffat Hills receive more snow than anywhere in Britain outside the Highlands. Hard frosts are frequent and after a severe winter, snow "wreaths" lie on the hills into early summer. This is probably the most southerly point in Britain at which late snow-lie effects begin to appear clearly in the vegetation. Snow tends to accumulate first and lie longest in the shelter of walls which traverse the high plateaux. On either side of these walls a narrow strip of *Nardus stricta* grassland marks the line of greatest snow accumulation and evidently corresponds to the *Nardus* snow-bed communities of the Highlands (*cf.* McVean, 1958). Elsewhere in the Moffat Hills, some of the high-level Nardetum is probably of this type.

Lying as it does in the heart of the Southern Upland sheep country, the Moffat area provides pasturage for large flocks of Cheviots and Blackfaces. Grouse, though still in some numbers on the gentler, more heathery hills sloping to the Meggat and the Tweed, are now a secondary concern. Deer are unknown in recent times, but parties of feral goats roam the hills perennially, and a herd is usually to be seen working the precipitous sides of the Tail gorge. Moor-burning is orthodox practice and in combination with the heavy grazing pressure, has had a drastic impact on the native vegetation. Nearly all woodland disappeared long ago, but a patch of sessile oak remains at Craigieburn to represent the type of forest which must once have covered the lower hillsides, on poorer soils. The birch and rowan growths in the lower ravines indicate that these trees were abundant on rocky slopes and above the zone of oak. Where such gorges are cut through basic rocks, as at the foot of Black's Hope, they contain fragments of mixed deciduous woodland, with oak, ash, elm and hazel, and a rich herbaceous ground flora.

On the drier hillsides, the forests and scrub have been replaced by heather and blaeberry communities, or by grasslands in which sheep's fescue, bents and mat-grass are the most important plants. The Moffat Water portion of the area is mainly grass or blaeberry-covered nowadays, but there is good evidence that Callunetum was once more widespread, and has largely been converted to the other types by heavy grazing and repeated burning. These hill-farming practices have, at the same time, been accompanied by soil erosion and scree formation on steep ground, and by the spread of bracken on dry soils at lower levels.

The gentler, drift-covered lower hillsides have moist grasslands with local dominance of *Molinia caerulea,* and an abundance of *Anthoxanthum odoratum, Festuca rubra, Agrostis* spp., *Carex* spp., and, sometimes, *Trichophorum caespitosum. Juncus acutiflorus* flush bogs occur in places and there are numerous flushes, which may be mossy, sedgy or mainly open and stony. Rich grasslands of a drier type, full of small herbs, occur on good soils, especially where there is periodic irrigation during wet weather. Acidic peat soils are extensive on the upper slopes and watersheds, and the shallower deposits have wet grassland with much *Nardus* and *Juncus squarrosus.* This passes into true blanket-bog on deep peat, with *Calluna* and *Eriophorum*

*vaginatum* as the usual dominants, but much *Sphagnum* on the wettest ground. In many places, particularly to the east of L. Skene, erosion has cut a maze of deep channels into the bogs.

Some vegetation types on the high tops show the effect of extreme exposure. The White Coomb has patches of completely prostrate and dwarfed heather carpet—a community characteristic of upper slopes in the Highlands, but totally eradicated everywhere else in the Southern Uplands by fire and sheep. The *Vaccinium* heaths and grasslands occur in modified form but pass on the highest ground into a community which locally approaches the true *Rhacomitrium* heath of the Highlands.

Nearly all these Moffat Hill communities are thus composed of plants which are in no way peculiar to high ground. In this present setting, the true montane plants represent a relict element of survivors from a bygone colder period, and though many are rare and all are insignificant in their contribution to the total bulk of vegetation, they hold strong interest from both the ecological and phytogeographical viewpoints.

## THE MOUNTAIN PLANTS.

The shattered rock-walls which flank the Grey Mare's Tail and the lesser falls above hold a particularly varied assortment of plants. The rotten shales are strongly charged with lime in places and calcicoles are much in evidence as a result. The montane element of the flora is here blended with a strong lowland and woodland group, for the foot of the fall lies at only 900 ft. Whereas the south-facing cliffs of the gorge are mostly dry, the sun-less northern aspect shows a prevalence of dripping rocks and moist ledges, with a more luxuriant vegetation. The constant dampness of the atmosphere, spray-drenched in time of flood, is revealed by the fine sheets of *Hymenophyllum wilsoni* which clothe the stream-side rocks in places.

The shaded north-east wall of the ravine has a profuse growth of *Sedum rosea, Oxyria digyna, Thalictrum minus* agg. and *Cochlearia alpina,* along with familiar upland meadow plants such as *Geranium sylvaticum, Trollius europaeus* and *Alchemilla glabra.* Along with other common herbs, sedges and grasses, these plants tend to form a dense vegetation on the bigger ledges, but some other species belong mainly to the barer rock-faces and crevices. Among the latter are *Saxifraga oppositifolia, S. hypnoides, S.*

*stellaris, Alchemilla wichurae* and *Asplenium viride.* Purple Saxifrage grows in some abundance on moist rocks alongside the main fall, but is now unknown elsewhere in the Southern Uplands. Drier, more acidic rocks support good colonies of *Silene maritima* and *Ramischia secunda*: both are widespread species in the Moffat Hills, the former occurring mostly on the high-lying crags, and the other less abundantly in the lower ravines. *Antennaria dioica* grows rather sparingly on dry rocks here, but has many localities in the area, both on basic outcrops and more acidic soils with a heathy vegetation. *Viola lutea* var. *amoena* occurs here and there in similar habitats but thrives best on shady rock ledges. Representatives of a sub-montane flora of rocky woods include, besides the more common herbs, *Circaea alpina, Rubus saxatilis, Melica nutans, Vicia sylvatica* and *V. orobus* (not seen recently). Some plants of southern chalk and limestone go high in the Scottish mountains, and two of these, *Arabis hirsuta* and *Helictotrichon pratense* are plentiful in the Tail ravine, as well as on more elevated crags. *Meum athamanticum* is locally plentiful as an upland wayside and pasture plant elsewhere in Southern Scotland but in the Moffat Hills seems to be known only in an unusual habitat, on a single rock-ledge above the Tail (K. Ross, pers. comm.).

Most of the strictly montane species named above grow on all the major outcrops of calcareous rock at high levels, as on the crags of White Coomb above Midlaw Burn; the Raven Craig and ravines at the head of Carrifran; and the extensive ranges of broken cliff in Black's Hope. Here they have the company of rarer plants which are restricted to fairly high altitudes. Some of these are plentiful within their special habitat, but others occur only in a very few places, and then sparingly. The group of lowland plants flourishes on these high rocks, though some species, such as *Ajuga reptans* and *Centaurea nigra,* do not occur much above 1,000 ft.

*Thalictrum alpinum* grows wherever there are wet, base-rich silty soils above 1,500 ft. on crag-ledges, grassy slopes, in stony flushes, or beside rills, but *Polygonum viviparum,* a plant of similar habitats, occurs much more sparingly and locally. *Saussurea alpina* and *Potentilla crantzii* have only a few colonies, on both moist, shady and dry, sun-exposed ledges and slabs. The remaining calcicoles are rarities, with only one or two stations each, and

all grow on open rocks where there is little competition. A rather degenerate-looking growth of *Salix lapponum* still survives on wet, shaded ledges of the White Coomb, but *S. myrsinites,* formerly known from the same area, has not been seen for many years and must be presumed extinct. Nearby, a range of crumbly rock bears scattered tufts of *Carex atrata, C. capillaris* and *Poa balfourii,* and each of the three has at least one other locality in the area. *Rhinanthus borealis* has been found on Carrifran and Black's Hope, its most southerly haunts known in Britain.

Single station plants are *Polystichum lonchitis, Cerastium alpinum, Saxifraga nivalis* and *Ajuga pyramidalis.* The holly fern is represented by a colony of about 30 plants, sprouting from mossy crevices of strongly calcareous rocks. *Cerastium alpinum* makes a good display on rather bare, dry rocks at about 2,000 ft. and alpine saxifrage has a fine cluster on another outcrop at a similar elevation. The latter is especially impressive in its localisation, with the total strength of nearly forty plants mostly growing within the same square yard of mossy, overhung rocks. The northern bugle has evidently not been seen except by its original finder, J. T. Johnstone but there is no reason to doubt the record.

Perhaps the most famous plant of the Moffat Hills is *Woodsia ilvensis.* There were once several stations and in one or two of these the fern grew in profusion. A century ago, these hills were the British headquarters of the species, but such was the cupidity of Victorian fern-hunters that in 1896, Scott-Elliott wrote that of the hundreds of plants existing fifty years before, only two then remained. G. C. Druce saw the supposed sole survivor in 1911. It is therefore gratifying to be able to record that this little fern still survives in at least one Moffat locality, where, in 1954, I found about 25 separate tufts growing on an outcrop of dry, shattered rocks at a moderate elevation.

Many plants of the basic rock ledges could grow equally well, and almost certainly did so before the advent of sheep, on the richer soils and flushes which occur widely on the mountain slopes. Individuals of the taller species, such as *Saussurea,* occur here and there on grazed turfy banks, but only the smaller plants are able to flourish away from the steep rocks. *Thalictrum alpinum* and *Saxifraga stellaris,* for instance, are abundant in flushes everywhere at high levels, with the former preferring basic

and the latter more acidic sites. Some plants belong more particularly to flushes and occur less often on wet rock ledges.

Immediately below the plateau of White Coomb, many springs emerge on the steeper grassy slopes, and pass into extensive flush communities of a characteristic type. The water supply contains only a moderate amount of mineral nutrient, as indicated by the abundance of plants such as *Montia fontana* agg., *Stellaria alsine* and *Chrysosplenium oppositifolium*. Montane plants are well represented in the spongy carpet, with a good deal of *Cochlearia alpina, Saxifraga hypnoides* and *S. stellaris,* and more local abundance of *Epilobium alsinifolium, E. anagallidifolium* and *Veronica serpyllifolia* subsp. *humifusa*. In such a community, *Alopecurus alpinus,* a species hitherto unknown south of the Highlands, was discovered as recently as 1956. About 30 flowering plants of the grass, growing as scattered individuals, were then counted by the writer. *Sedum villosum* grows in rather similar flushes at over 2,000 ft. on Black's Hope, but occurs elsewhere below 1,000 ft. and in more calcareous types. The eutrophic springs and flushes of the lower slopes have very few mountain plants, but the submontane *Parnassia palustris* is frequent.

The high-level springs and flushes often feed small patches of bog with a dense, sedge-dominated vegetation. One of these marshes, high on Hart Fell, contains no fewer than twelve species of *Carex,* including the bog form of *C. bigelowii* and *C. vaginata,* here in its most southerly British locality.

The predominant vegetation types of these hills, acidic grasslands, heaths and blanket-bogs, are composed largely of calcifuge plants, and the poverty of their soils is matched by that of their flora. The grasslands are especially poor in mountain species, and only very locally do the more elevated blaeberry and heather clad hillsides produce any of these plants. *Lycopodium alpinum* and *L. selago* are, however, more plentiful on the upper slopes than elsewhere. The rocky northern slopes of White Coomb have an abundance of *Empetrum hermaphroditum,* and there are a few patches of *Chamaepericlymenum suecicum* in mixed *Calluna-Vaccinium* heath. *Listera cordata* occurs sparingly in such vegetation, but *Vaccinium uliginosum* is rare, and has been seen recently in this area only on heathy rock-ledges. *Arctostaphylos uva-ursi* formerly grew on rocky ground of White Coomb and Carrifran, but seems to have disappeared. It is likely that the repeated

burning of the heathery vegetation with which the plant was probably associated has destroyed the bearberry. There are clear signs that on both the slopes and broken crags of White Coomb, the former extent of heather ground has been greatly reduced in recent years, and in steep places, the beginnings of soil erosion are well established.

The extensive *Calluna-Eriophorum* blanket-bogs of the more elevated flats and broad watersheds have a distinctive plant in *Rubus chamaemorus*. The cloudberry grows in great luxuriance and often fruits well on the peaty tracts around the Midlaw and Tail Burns, and ascends to the highest ground at nearly 2,700 ft. Its abundance in this district contrasts with its virtual absence from the Galloway Hills to the west. On one boggy shoulder, cloudberry grows with *Chamaepericlymenum suecicum* and on a patch of blanket-bog below the top of Saddle Yoke, it has the company of *Vaccinium uliginosum*.

The screes which have spread over so many steeper slopes are often thickly studded with large clumps of *Cryptogramma crispa,* though this fern occurs on outcrops as well. The parsley fern grows more luxuriantly on these hills than in most parts of the Highlands. On the Garelet Hill and above Loch Skene, where the rock debris is fairly basic, *Saxifraga hypnoides* acts as a scree "pioneer", growing abundantly in dense clumps and mats. This plant often thrives amongst the blocks of rocky watercourses, there forming compact cushions.

The high summits are relatively barren plant ground, though the distinctive vegetation type dominated by *Rhacomitrium lanuginosum* and *Festuca ovina* has two characteristic species in *Carex bigelowii* and *Salix herbacea*. The mountain sedge is common but the least willow more local, on stony ground. On the windswept tops, *Salix herbacea* is extremely dwarfed, but grows much larger on more sheltered cliff faces.

## DISCUSSION.

Although the country just north of the Moffat Hills contains even higher ground, on Broad Law and Cramalt Craig, the mountain flora is poor by comparison and contains little but the calcifuge element, such as *Rubus chamaemorus* and *Chamaepericlymenum suecicum*. The other adjacent hill areas are rather lower and even poorer in montane plants. The Galloway Hills

are comparable in height with those near Moffat, but though more rugged, their flora is greatly inferior. Moreover, as noted, the Peebles and Selkirk portions of the Moffat Hills have no special attractions botanically and the concentration of species is on Moffat Water itself.

This remarkable localisation of montane plants in the Southern Uplands is to be explained by the scarcity of suitable refuges. These survivors of a Late-Glacial flora are adapted to a cool climate, and so only the higher hills provide conditions which suit their needs. It is likely that all these plants once grew on the lower hills—and in the lowlands—but were exterminated on all but the high ground by the spread of more luxuriant vegetation types, especially woodland; and by the direct effect of adversely high temperatures. Added to this climatic limiting factor are other exacting requirements. The majority of British mountain plants need lime-rich soils; many cannot compete successfully in a dense, closed vegetation, and these need open soils; and others require protection from the heavy grazing which is now universal over the Southern Uplands. The last two needs are satisfied on cliff-faces. Moreover, even on basic rocks, leaching and acidic humus accumulation are so active that only on flushed or unstable, rocky ground are base-rich soils maintained. The general requirement is thus for high altitude, and calcareous rocks occurring extensively as steep outcrops. Only in the Moffat Hills are all these conditions satisfied. The Broad Law group is sufficiently high and has suitable parent rocks, but there are no crags worth mentioning; whilst the Galloway Hills are high and rugged, but have very little calcareous rock. In addition, the more continental climate of the Moffat Hills may have favoured the survival of a richer montane flora than the oceanic conditions of the western hills.

The same factors which explain the scarcity of montane plants within the Southern Uplands as a whole also account for the rarity of many species within the Moffat Hills. In this area many plants are rare simply because suitable habitats are scarce; this is particularly true of those which need strongly calcareous rock ledges. Some mountain plants are able to grow at lower elevations than others, and so tend to be the common species, since they have a greater number and extent of habitats available to them. By contrast, the rarities, and especially the single

station plants, are usually confined to high levels. The absence of a species from apparently suitable sites is largely a matter of chance—either it was never able to reach these spots, or else it died out there and has not returned. Most of the common species such as *Sedum rosea, Oxyria* and *Saxifraga hypnoides* are able to spread by seed, and so occupy most of the suitable habitats. Those which have been unable to do likewise have perforce become rare, and these are the true relicts, hanging on in a few scattered places or perhaps in a single locality. Plants such as *Saxifraga nivalis, Cerastium alpinum* and *Carex atrata* evidently exist now under conditions which are sub-optimal. Their powers of reproduction suffice only to maintain their remaining small populations, and may even be inadequate for this. Relicts are quite likely to die out entirely, and the disappearance of *Salix myrsinites* from the White Coomb is a local instance. The greater abundance of these rare Moffat species in parts of the Scottish Highlands is a reflection not only of the much greater extent of suitable edaphic habitats, but also of a more favourable, colder climate.

In that they are much less limited by lack of suitable habitats, some of the calcifuges show these points better. *Rubus chamaemorus* is common in all the high blanket-bogs, but has a fairly well defined lower limit at about 1,400 ft. *Salix herbacea* has not been seen below 1,900 ft., but is locally plentiful above this level. *Chamaepericlymenum suecicum* and *Vaccinium uliginosum,* on the other hand, are very rare within their altitudinal zone (above 1,900 ft.) and have highly relict distributions. The first two plants are evidently restricted to the higher ground because the climate is unfavourable at lower levels, but they flourish within their altitudinal zone. The second pair present a more difficult problem and their rarity is best explained in terms of a more drastic restriction by unfavourable climate during Post-Glacial time, and the subsequent inability of the survivors to spread.

A few British mountain plants are rather surprisingly absent from the Moffat Hills, as for instance, *Alchemilla alpina** and *Saxifraga aizoides**, both of which are abundant in the Highlands and the Lake District, not far to the south. *Silene acaulis, Dryas octopetala, Juncus triglumis** and *Poa alpina* are widespread British species which are missing from this area, and *Saxifraga oppositifolia* is unaccountably scarce. Some common Highland

plants such as *Gnaphalium supinum, Luzula spicata, Juncus trifidus** and *Sibbaldia procumbens** are likewise absent. *Saxifraga hirculus* is the only true mountain plant which is unknown in the Moffat Hills but present elsewhere in the Southern Uplands. A rather long list of old and doubtful records includes those species marked above with an asterisk, together with *Lycopodium annotinum, Betula nana, Carex saxatilis, C. rupestris, Juncus castaneus, Tofieldia pusilla* and *Veronica alpina.* Some of these may yet be present, in small quantity, others may have died out, and others still are likely to have been recorded in error. *Myosotis brevifolia* has evidently not been seen in recent years, but probably still occurs.

It is possible that all these plants may have occurred in the area during the Late-Glacial Period and have since been lost, but there is a chance that some of them were missing from the flora which followed the retreating ice in this area.

## Appendix I.

### Moffat communities containing montane plants.

Brief mention has been made of the vegetation types with which the various montane plants are associated, and the floristic composition of these is described more fully in the following lists. Letters are the conventional symbols of frequency.

Nomenclature is according to the following:—

Vascular plants: Clapham, Tutin and Warburg (1952)
Mosses: Richards and Wallace (1950)
Liverworts: Jones (1958)
Lichens: Watson (1953)

1. *Vegetation of basic cliffs.*

This could include a heterogeneous collection of plants, for on a single cliff there are great variations in micro-topography and soil conditions. Habitat sub-divisions could be made, but sufficient has been said already to indicate the kind of fragmentary "communities" on crags. The list below includes all the species confined to steep basic rocks and those which, though abundant on other ground, are especially prominent in such places.

(a) Species present on all, or nearly all, the major outcrops (for list of sites see text) at 900-2,500 ft.

Alchemilla glabra*
A. vestita
A. wichurae
Angelica sylvestris
Antennaria dioica
Asplenium viride
Botrychium lunaria
Carex demissa*
C. flacca*
C. pallescens
C. panicea*
C. pulicaris*
Cochlearia alpina*
Crepis paludosa
Cystopteris fragilis
Deschampsia caespitosa
Festuca rubra*
F. vivipara
Filipendula ulmaria
Galium boreale
Geranium sylvaticum
Geum rivale
Heracleum sphondylium
Lathyrus montanus
Linum catharticum*
Oxyria digyna
Pimpinella saxifraga
Pinguicula vulgaris*
Polygonum viviparum
Saxifraga hypnoides*
Sedum rosea
Selaginella selaginoides*
Succisa pratensis
Taraxacum officinalis agg.
Thalictrum alpinum*
T. minus agg.
Trollius europaeus
Valeriana officinalis
Amphidium mougeotii
Anoectangium compactum
Anomobryum filiforme*
Blindia acuta
Brachythecium plumosum
Breutelia chrysocoma
Bryum pseudotriquetrum*
Campylium protensum
C. stellatum*
Cratoneuron commutatum*
Ctenidium molluscum*
Drepanocladus revolvens*
D. uncinatus
Fissidens adianthoides*
F. cristatus
F. osmundoides
Grimmia apocarpa
Mnium punctatum*
M. undulatum
Neckera crispa
Plagiobryum zierii
Pohlia cruda
Tortella tortuosa
Riccardia pinguis*
Tritomaria quinquedentata
Pellia fabbroniana
Plagiochila asplenoides
Preissia quadrata

Species marked with an asterisk commonly form the vegetation of calcareous flushes on the hillsides.

(b) Rarer species with only one or a few stations.

Ajuga pyramidalis (1) —
Carex atrata (3) 2
C. capillaris (3) 1
Cerastium alpinum (2) 1
Circaea alpina (1) —
Epilobium alsinefolium (4) 3
Helictotrichon pratense (2) 2
Melica nutans (—) 1
Poa balfouri (1) 3
Polystichum lonchitis (1) 1
Potentilla crantzii (5) 3
Rhinanthus borealis (2) —
Rubus saxatilis (1) 2
Salix lapponum (2) 1
(S. myrsinites) (1) —
Saussurea alpina (5) 4
Saxifraga nivalis (1) 1
S. oppositifolia (1) 1
Vicia orobus (3) —
V. sylvatica (2) 2
Viola lutea (4) 2
Woodsia ilvensis (5) 1

Lejeunea patens
Metzgeria hamata
Porella laevigata
Radula lindbergiana
Trichocolea tomentella
Amphidium lapponicum
Barbula ferruginascens
Distichium capillaceum
Encalypta ciliata
Grimmia funalis
G. torquata
Hypnum callichroum
Mnium marginatum
Orthothecium intricatum
Plagiobryum zierii
Plagiopus oederi
Pseudoleskea catenulata†
Ptilium crista-castrensis
Rhacomitrium ellipticum
Rhytidium rugosum†
Seligeria pusilla

Bracketed figures for the vascular plants give the number of recorded localities.
The other figures give number of localities seen recently.
† Old and unconfirmed records.

2. *Vegetation of acidic cliffs.*

Nearly all the plants of acidic grassland and heath grow on the base-poor outcrops, but the following is a list of species most characteristic of such rocks.

(a) Species present on nearly all the higher ranges at 1,500-2,500 ft.

Carex bigelowii
Festuca vivipara
Hymenophyllum wilsoni
Luzula sylvatica
Lycopodium selago
Salix herbacea
Saxifraga stellaris
Silene maritima
Solidago virgaurea
Succisa pratensis
Vaccinium vitis-idaea
Gymnomitrium concinnatum
G. obtusum
Campylopus atrovirens
Grimmia doniana
Isopterygium elegans
Mnium hornum
Plagiothecium denticulatum
Pohlia elongata
Rhacomitrium aquaticum
R. heterostichum
R. lanuginosum

Ramischia secunda would be included at lower levels.

(b) Rarer species with only one or a few stations.

(Arctostaphylos uva-ursi)
Vaccinium uliginosum
Arctoa fulvella
Cynodontium polycarpum
Dicranoweissia crispula
Dicranum falcatum
Grimmia atrata
G. incurva
G. patens
Oedipodium griffithianum
Pohlia acuminata

3 *High-level spring communities.* White Coomb at 2,500 ft.

| | | | |
|---|---|---|---|
| Agrostis stolonifera | a | Stellaria alsine | va |
| Alopecurus alpinus | o | Veronica serpyllifolia subsp. humifusa | f |
| Anthoxanthum odoratum | a | Aplozia cordifolia | ld |
| Caltha palustris subsp. minor | f | Chiloscyphus pallescens | f |
| Carex bigelowii | f | Scapania undulata | a |
| C. echinata | a | Acrocladium cuspidatum | f |
| Cerastium vulgatum | f | Bryum pseudotriquetrum | f |
| Chrysosplenium oppositifolium | ld | B. weigelii | f |
| Cochlearia alpina | a | Dicranella squarrosa | f |
| Deschampsia caespitosa | f | Drepanocladus exannulatus | a |
| Epilobium alsinifolium | la | Mnium undulatum | f |
| E. anagallidifolium | f | Philonotis fontana | va |
| Festuca rubra | a | Sphagnum squarrosum | f |
| Montia fontana agg. | va | S. subsecundum var. auriculatum | f |
| Poa trivialis | f | Splachnum vasculosum | o |
| Ranunculus acris | a | | |
| Saxifraga hypnoides | f | | |
| S. stellaris | a | | |

4. *High-level heath.* White Coomb at 2,000 ft.

| | | | |
|---|---|---|---|
| Agrostis canina | a | Vaccinium myrtillus | ld |
| A. tenuis | a | V. vitis-idaea | a |
| Blechnum spicant | f | Barbilophozia floerkii | f |
| Calluna vulgaris | f | Diplophyllum albicans | f |
| Chamaepericlymenum suecicum | l | Ptilidium ciliare | o |
| Deschampsia flexuosa | a | Dicranum scoparium | a |
| Empetrum hermaphroditum | la | Hylocomium splendens | a |
| Festuca ovina agg. | a | Hypnum cupressiforme | a |
| Listera cordata | o | Pleurozium schreberi | a |
| Luzula sylvatica | f | Rhytidiadelphus loreus | a |
| Nardus stricta | a | | |

The liverworts *Anastrepta orcadensis, Anastrophyllum donianum* and *Bazzania tricrenata* occur rarely in similar communities elsewhere.

5. *High-level blanket-bog.* Saddle Yoke at 2,200 ft.

| | | | |
|---|---|---|---|
| Calluna vulgaris | cd | Hylocomium splendens | f |
| Empetrum nigrum | va | Pleurozium schreberi | f |
| Eriophorum angustifolium | va | Rhacomitrium lanuginosum | a |
| E. vaginatum | cd | Rhytidiadelphus loreus | f |
| Juncus squarrosus | f | Sphagnum fuscum | o |
| Rubus chamaemorus | a | S. papillosum | ld |
| Trichophorum caespitosum | o | S. rubellum | ld |
| Vaccinium myrtillus | f-a | S. russowii | o |
| V. uliginosum | la | S. tenellum | f |
| V. vitis-idaea | a | Cladonia sylvatica | a |
| | | C. uncialis | f |

6. *Rhacomitrium heath.* Carrifran Gans at 2,450 ft.

| | | | |
|---|---|---|---|
| Agrostis canina | va | Dicranum scoparium | a |
| Carex bigelowii | va | Hylocomium splendens | o |
| C. pilulifera | a | Hypnum cupressiforme | o |
| Deschampsia flexuosa | va | Pleurozium schreberi | va |
| Empetrum nigrum | f | Polytrichum alpinum | f |
| Festuca ovina agg. | cd | Rhacomitrium lanuginosum | cd |
| Galium hercynicum | a | Rhytidiadelphus loreus | va |
| Luzula campestris | a | Cetraria islandica | f |
| Salix herbacea | f | Cladonia sylvatica | a |
| Vaccinium myrtillus | va | | |
| V. vitis-idaea | va | | |

## Appendix II.

### soil analyses.

The following two soil analyses, kindly carried out by Miss M. C. Gray, are both from calcareous rock ledge habitats in the Grey Mare's Tail ravine. Sample A is from a more or less closed community of tall herbs on a broad shelf, whilst B is from small, open ledges with a sparse plant growth which includes *Saxifraga oppositifolia*.

| | pH | % loss on ignition | $P_2O_5$ | CaO | $K_2O$ | $Na_2O$ |
|---|---|---|---|---|---|---|
| | | | | (all % dry weight) | | |
| A | 6·8 | 36·12 | 0·0017 | 0·973 | 0·048 | 0·027 |
| B | 6·4 | 13·86 | 0·0006 | 0·342 | 0·012 | 0·008 |

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# The Habitat of Koenigia islandica L. in Scotland.

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The discovery of *Koenigia islandica* as a member of the Scottish flora in Sky and Mull (Burtt, 1950; Corner, 1957) added yet another species to a not inconsiderable list of plants with a limited and disjunct distribution in Britain which are much more common elsewhere.

Though exceedingly limited in its distribution in Britain, *Koenigia* is widespread in sub-arctic areas and has an almost circumpolar distribution. Its habitats outside the British Isles are well known and well described in the literature (Hausen, 1930; Polunin, 1940; Gröntved, 1942; Hultén, 1944) and there is, therefore, a considerable body of data for comparison with the information obtained from Scottish localities.

The species is of especial interest because it is an annual, and its survival in any one locality must depend upon complete continuity of the appropriate habitat conditions. Godwin (1956) has shown that during late glacial times (Zone III) *Koenigia* was present in a part of Scotland (Berwickshire) widely separated from its present area. The record is based upon a single pollen grain, so too much weight cannot be placed upon this evidence, but the implication is that *Koenigia* was much more widespread in Britain in late glacial times (when the climate here approximated to that in present-day sub-arctic areas) than it is today. If this is so, then it is not unreasonable to assume that since then its area of distribution has been progressively reduced to the present limits on Skye and Mull. These two localities have two features in common: they are both on the Tertiary basalt of western Scotland and they are both above 1,500 feet. However, there are several areas in the Western Highlands and Islands combining these characteristics but from these *Koenigia* is apparently absent. We may then ask whether the localities on Skye and Mull possess special features favourable for the survival of the species, or whether this is merely due to chance factors. As a result of a visit to certain Tertiary basalt mountains in Morvern, Ardnamurchan and Skye in August, 1958, I believe that it is possible to provide at least part of the answer to this question.

The mountain known as The Storr, Skye, forms part of a massive escarpment of basalt, conspicuous as a series of east-facing cliffs extending north to south for several miles; behind the cliffs are much gentler west-facing slopes. The lower slopes have a thick blanket of peat and the flora is very poor, but the summit, apart from the cliffs, has moderately steep slopes which are well-drained and bear quite a rich grassland. However, owing to the easily-weathered nature of the rock, open habitats are frequent and on The Storr, as on other mountains nearby, *Koenigia* may be found in considerable quantity in three rather different situations (see Raven, 1952):

(1) Wet, stony patches just below the summit, often with shallow standing water with *Carex* spp. and bryophytes.
(2) Drier, less stony places with very few accompanying species except the moss, *Oligotrichum hercynicum*.
(3) Semi-stable screes of loose stony soil, associated with little but *Cardaminopsis petraea*.

Superficially, these habitats are dissimilar but closer examination shows that the soils are physically very much alike: loose-textured red-brown skeletal soils with little, if any, humus, a pH between 5·4 and 6·0, and few particles greater than $\frac{1}{2}''$ in diameter.

The first habitat type seems to owe its presence to a spring line which extends for some distance at about 2,200 ft. (200 ft. below the summit) and is apparently less extensive now than it was in the past, for dry stony areas otherwise exactly similar occur as a northward extension. The other two types of habitat seem to have been considerably extended in recent times owing to excessive grazing and breaking up of the turf by sheep.

The basalt mountains of Morvern and Ardnamurchan, though very similar to The Storr in many respects, differ in certain ways, of which perhaps the most important is that open habitats of the first type above are virtually absent. This appears to be connected with the fact that the summits are much less steep and a deposit of peat extends over everything except the steepest slopes and may even continue to the edge of the cliffs, so that grassland of the type on The Storr is rarely found; this is also true of the Quirang, Skye, on which *Koenigia* is apparently not present. In addition, the screes below the cliffs appear to be rather more active and unstable and so may form a less suitable habitat for such a small annual species.

Another factor which may be of importance in determining the distribution of *Koenigia* is the prevalence of cloud on the mountains on which it grows. Certainly, on four out of the six days which I spent in Skye, cloud covered the upper parts of all the mountains on which it is known to grow and it may be of significance that the lower limit of cloud on The Storr on those days corresponded exactly to the lower limit of *Koenigia islandica*, which does not grow below 1,500 feet despite an abundance of suitable habitats. In Morvern and Ardnamurchan only the summits seemed to be frequently covered in cloud and the cliffs and screes below them were often cloud-free and much drier.

Examination of the available literature reveals that *Koenigia* is not infrequently found in open habitats associated with solifluction phenomena. Polunin (1940) states that it occurs "on open muddy areas such as the surface of 'polygons', even if they become quite dry in summer". Weber (1955) describes its habitat in a newly-discovered locality in the Colorado Rocky Mountains as "gravelly polygons and sand bars of inlet streamlets feeding Summit Lake, Mount Evan, 12,700 feet". It is therefore noteworthy that Fitzpatrick (1958) records stone polygons on the summit of The Storr; I have not seen these personally, as I only discovered the record on returning from Skye, but they must be very close to the habitats of *Koenigia*. I did notice, however, that the steeper slopes immediately below the summit are characterised by the presence of distinct 'soil-creep terraces' or 'debris terraces' as Fitzpatrick terms them. Fitzpatrick apparently considers the polygons to be contemporary features, but the climate of Skye is rather mild, even at 2,000 ft., and it is difficult to believe that they are being actively formed at the present time. The soil terraces do not seem to be active now, as they are covered by a uniform vegetation, predominantly of grasses, unlike those of the Cairngorms and other areas (Watt and Jones, 1948). If, indeed, these solifluction features are not merely contemporary then their presence is of considerable significance, for they may indicate that open habitats suitable for *Koenigia islandica* have been continuously present in Skye for a very long time. It may be in this respect that the Skye and Mull localities have been peculiarly favourable for the survival of the species, possibly since late glacial times—both localities lie outside the moraines marking the Highland Readvance, dated

by Donner (1958) as Zone III of the late glacial. The basalt mountains of Morvern and Ardnamurchan which I have seen apparently do not possess any marked solifluction features but on one of the more inaccessible mountains in Morvern, Ben Iadain (1873 ft.), stone polygons have been reported; they "occur on level or gently sloping ground where a loose blanket of soil, 6 to 12 inches thick, overlies solid rock (basalt)", a description which reminds one strongly of the summit of The Storr. I think that if *Koenigia* is to be found on the mainland at all, this is a most promising area.

Briefly summarising, it can be said that The Storr, Skye, differs from certain basalt mountains in other areas in a way which might explain why the locality has been favourable for the survival of *Koenigia islandica*:

1. Springs and flushes are less frequent or absent near the summits of the basalt mountains on the mainland, and peat is much more widespread.
2. The other habitats suitable for *Koenigia* are on the whole lower down their slopes and below the level of prevalent cloud.
3. The Storr is unusual in possessing features associated with solifluction, possibly indicating the continuous presence of open habitats since late glacial times.

It is hoped that a visit to Mull in 1959 will provide evidence for or against the above hypothesis.

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# Additions to the Flora of Foula (V.-C. 112).

By K. Guy Messenger
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and
J. Gordon Urquhart.

(Received, 4th December, 1958.)

The remote island of Foula, long by-passed by botanists, has been visited twice recently, and records of the flora (which was earlier listed by Turrill (1929) using specimens collected in 1928 by J. Gladstone) have been augmented.

In the summer of 1956, K. G. Messenger, in charge of a number of boys of the Brathay Exploration Group, carried out extensive observations and made a collection of specimens later presented to the herbarium of the Science Department of Uppingham School. In August, 1957, J. G. Urquhart made a further collection of specimens which are now deposited in the Herbarium of the Royal Botanic Garden, Edinburgh. The following list summarises the two sets of observations. Nomenclature follows Dandy (1958).

## New Records.

Equisetum palustre L. Slope below Leiraback, 1956.

E. arvense L. South end of island, 1957.

Athyrium felix-femina (L.) Roth. Waters of Sneug, occasional. Specimen not confirmed, 1957.

Polypodium vulgare L. Below Leirabeck, locally frequent, 1956 and 1957.

Sinapis arvensis L. Arable weed, Ham, 1956.

Cakile maritima Scop. Ham Voe, 3 plants only, 1957.

Lepidium sativum L. Nurse's Cottage, 1957.

Viola palustris L. Common in damp places, identification based on vegetative characters only, 1957.

Polygala serpyllifolia Hose. Occasional in marshes and damp ground. Blue, pink and white forms. Turrill (1929) records *P. vulgaris* 1956 and 1957.

Silene alba × dioica. Old Kirkyard, 1957.

Montia sibirica (L.) Howell. Blobersburn. Identification based on vegetative characters only, 1957.

Atriplex patula L. Nurse's Cottage, frequent weed in garden, 1957.

A. glabriuscula Edmonst. Ham Voe and shore below Hametoun. Locally frequent, 1956 and 1957.

Geranium pratense L. Outside School garden wall, introduced, 1956.

Rubus sp. Helligoland Trap, Ham. Possibly reverted Loganberry. Introduced, 1956.

Chamaenerion angustifolium (L.) Scop. Outside school-house wall, 1956.

Callitriche intermedia G. F. Hoffm. Sterile spec. obtained from Ham Burn, near mouth, 1957.

Polygonum persicaria L. Cornfield weed, uncommon, 1956 and 1957.

P. cuspidatum Sieb. & Zucc. In several ruined crofts, and beside Ham Burn. Introduced, 1956 and 1957.

Urtica urens L. School-house, waste-ground, 1957.

Glaux maritima L. South Ness, cliff-tops, 1956 and 1957.

Myosotis secunda Murr. North of Mill Loch, marsh, 1956 and 1957.

M. caespitosa K. F. Schultz South side of Ham Burn, marsh, 1957.

Calystegia sepium (L.) R.Br. Side of Ham Burn, south of Gravins, 1956 and 1957.

Mimulus guttatus DC. By Ham Burn, introduced by H. Holbourn, 1953, 1956.

Digitalis purpurea L. On garden wall at Leirabeck, introduced, 1956.

Pedicularis palustris L. Marshy areas at Harrier and Mill Loch, 1956 and 1957.

Rhinanthus minor agg. Common in grassland, 1956 and 1957.

Euphrasia frigida Pugsl. Veedal, grassland, 1957.

E. nemorosa (Pers.) Wallr. Veedal, grassland, 1956.

E. borealis Wettst. Fields and roadside, lowland, 1956.

E. brevipila Burnat & Gremli. Veedal, grassland, 1957.

Mentha spicata L. Mouth of Ham Burn, escape from cultivation at Post Office, 1956.

M. × smithiana R. Grah. Mouth of Ham Burn, 1957.

Glechoma hederacea L. In ruins of Stoel Croft only, 1956.

Plantago maritima L. Abundant on shore. Some well-grown plants inland on moors, 1956 and 1957.

Galium aparine L. Patch at mouth of Ham Burn, 1956.

Gnaphalium uliginosum L. South end of island, dry sandy soil, rare, 1957.

Potamogeton pectinatus L. Mill Loch, 1957.

Juncus bulbosus L. North-east of island, damp ground, 1957.

Luzula multiflora (Retz.) Lej. Hanmafelt, 1,000 ft., uncommon, 1957.

Sparganium angustifolium Michx. Sandvadden Loch, Overfandal Loch, Mill Loch, peat pool on Overfandal, 1956.

Carex hostiana DC. Near Blobersburn, 250 ft., 1956.

C. demissa Hornem. Mucklegrind, 250 ft., North Veedal, 50 ft., 1956 and 1957.

C. echinata Murr. Below Soberlie, 1956.

Sieglingia decumbens (L.) Bernh. Moorland, not uncommon, 1956.

Festuca rubra L. Common, 1956 and 1957.

Poa annua L. Wester Hoevdi, 500 ft., and elsewhere in grassland, 1956.

P. pratensis L. By Ham Burn, 1956.

Agropyron repens (L.) Beauv. In front of Haa and Ham Voe, 1956 and 1957.

Elymus arenarius L. By Ham Burn, introduced and flourishing, 1956.

Avena sativa L. Path-side near Brae, an escape from cultivation, 1956.
Arrhenatherum elatius (L.) J. & C. Presl. Steep bank between Leiraback and Ham Burn, 1956.
Agrostis tenuis Sibth. 1956.
A. canina ssp. montana (Hartm.) Hartm. Moorland, 1956.
(The specimen of *Agrostis canina* L. collected in 1957 is of interest in that it is infected by the smut *Tilletia decipiens* as was Gladstone's specimen in 1928.)
A. tenuis × stolonifera. 1956.

Species Previously Recorded, but not Confirmed in 1956 or 1957.

Selaginella selaginoides (L.) Link. No. 29, Grisigarth (Turrill, 1929).
Pteridium aquilinum (L.) Kuhn. Quivrigill, c. 200 ft., relics of a once extensive patch (Turrill, 1929).
An exhaustive search in 1956 failed to reveal any trace of this species in this area. Said to have disappeared after the severe winter of 1947.
Brassica oleracea L. Washed down the Ham Burn (Turrill, 1929).
Polygala vulgaris L. (Turrill, 1929).
Rumex longifolius DC. Established in Kirkyard. Specimens too young to be determined with certainty (Turrill, 1929). Only *R. crispus* found in churchyard, 1957.
Loiseleuria procumbens (L.) Desv. (Lewis, 1911).
Arctous alpinus (L.) Nied. High ground (Lewis, 1911).
Pedicularis sylvatica L. No. 85. Frequent on exposed plateau (Turrill, 1929).
Only *P. palustris* found in 1956-57.
Littorella uniflora (L.) Aschers. Sukkimires (Turrill, 1929).
Avena strigosa Schreb. No. 34. Ssp. *orcadensis* grown from seed (Turrill, 1929).

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# Rhizoctonia solani and Orchid Seed.

By D. G. Downie
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(Received 11th December 1958.)

In a previous paper it was shown that *Rhizoctonia solani* Kühn. occurs frequently as an endophyte in the roots of *Orchis purpurella* T. & T. A. Steph., and that strains of the fungus, from the orchid and from non-orchid hosts, stimulate embryo development and seedling growth (Downie, 1959). As the growth habit of the pathogen in culture is very similar to that of the *Rhizoctonia* endophytes isolated from many orchid species, experiments were devised to test the reaction of *R. solani* with the seed of a number of orchids. In Scotland orchids flowered abundantly in the summer of 1958 but owing to the unfavourable weather in July and August capsule formation was poor. The seed proved non-viable in some species and in others the percentage germination, when estimated by asymbiotic methods, was exceedingly low. The test is, therefore, not as extensive as had been hoped but the results seem to warrant a preliminary report. The experiment was confined in the main to British orchids, but one Madeira (*Orchis foliosa* Soland.) and one cultivated hybrid (*Vanda tricolor* × *V. suavis*) were included. Where the symbiont of the orchid species had been isolated previously and maintained in culture, a comparison of the growth stimulus obtained with the natural endophyte and with the pathogen was made. Nine strains of *R. solani* (three isolated from *O. purpurella* and six from non-orchid hosts) were tested for their effect on the seed of ten orchid species and the results show that the embryos of a number of orchids can be stimulated by this fungus.

The experimental methods employed were similar to those described in previous papers (Downie, 1940). The seed was surface sterilised with calcium hypochlorite and sown on substrates consisting of a solution of nutrient salts, with the addition of either 0·1% glucose or 0·1% potato starch, solidified with 1·5% agar. In the case of *Vanda* and of *Listeria ovata* (L.) R. Br., however, sucrose was substituted for glucose in the medium. The series consisted of tubes without any fungus (control), with the

TABLE I.

| Orchid Species | Fungi | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Associated Endophyte | Endophyte of *Platanthera bifolia* | *Rhizoctonia solani* | | | | | | | | |
| | | | Hosts of *Rhiz. solani* | | | | | | | | |
| | | | *O. purpurella* | | | Tomato | Cauli-flower | Potato | Wheat | Rice | Oil Palm |
| | | | B12 | C1 | L10 | RS1 | RS5 | RS6 | CS1 | RS10 | RS11 |
| Orchis purpurella | | | S | S | S | S | s | s | s | S | O |
| Orchis ericetorum | O | | O | P+ | S | S– | P+ | O | O | S | P |
| Orchis foliosa | | S | P | O | S | S– | O | O | O | S– | O |
| Coeloglossum viride | S | | O | P | S– | P | O | O | O | S– | P |
| Corallorhiza trifida | | | P | O | O | | | | O | O | |
| Goodyera repens | S | | | | S– | | | | | S– | |
| Gymnadenia conopsea | O | | O | O | O | P | O | O | O | S– | O |
| Leucorchis albida | O | | P | P | O | O | O | O | O | O | P |
| Listera ovata | S | | O | P | O | | O | O | O | O | |
| Neottia nidus-avis | | O | P | O | O | O | O | O | O | O | O |
| Vanda tricolor × V. suavis | | S– | | P | P | | | | O | S | P |

S=symbiosis and rapid growth; s=symbiosis and slow growth; S–=partial symbiosis; O=no infection; P+=stimulation then parasitism; P=parasitism.

endophyte normally associated with the orchid, where available, and with the experimental strains of *R. solani*. Where the natural symbiont was not available, the endophyte from *Platanthera bifolia* (L.) L. C. Rich was substituted, as this fungus is readily accepted by a number of orchids. All experimental material was set up in triplicate where seed was scarce, or in quadruplicate where seed was abundant. The cultures were incubated at 20°C. in darkness for two months and then exposed to diurnal light in the laboratory for a further 2-3 weeks before the results were estimated. The seed in the control tubes (without fungus) either remained dormant or the embryos enlarged and ruptured the seed coat. The soluble carbohydrate content in the experimental media is so low that growth was negligible even with species which normally develop asymbiotically on a sugar medium.

The results are expressed in Table I.

To indicate more fully the results of the experiment the meanings of the symbols used are expanded as follows:—

B12, C1, etc., represent strains of *R. solani*.

O This symbol is used to denote the non-entry of the fungus into the tissues of the embryo. It also includes a condition where a few embryos show hyphal coils in one or two isolated cells but the mycorrhizal state is not established and no growth occurs.

P The majority of embryos are invaded and active hyphae are observed in all cells of the host. No growth takes place and a state of parasitism is recognised.

P+ The fungus invades the host and at first a growth stimulus occurs so that the embryos develop into small protocorms. The control mechanism of the orchid is, however, inefficient and soon the invasion of hyphae passes to all cells and the protocorms are killed.

S Controlled invasion or symbiosis; host cells and digestion cells are observed in the lower half to two-thirds of the developing protocorms; the meristematic region remains unattacked; there is a relatively high percentage germination followed by rapid growth of the protocorms.

s Controlled invasion or symbiosis as above but the growth rate of the protocorms is much reduced.

S– This condition is found with many orchid species when associated with *R. solani*. It is characterised either by a very

low initial germination and the development of only 3 or 4 large protocorms in each tube or good germination followed by the early death of the majority of protocorms so that again only 3 or 4 survive. The surviving protocorms continue to grow (for at least 6 months in the case of *Goodyera repens*); host cells and digestion cells are present in the basal area of the protocorms; the growth rate is much lower than that attained with true symbiosis.

*Orchis purpurella* T. & T. A. Steph. As previously noted this orchid readily accepts *R. solani* as a symbiont under natural conditions. The experiment shows that certain strains of the fungus are more effective growth stimulators than others but it is remarkable that a balanced mycorrhizal association can be attained between this orchid and all forms of the pathogen tested, except RS11.

*Orchis ericetorum* E. F. Linton. Unfortunately the endophyte isolated from the roots of this orchid did not stimulate germination so that no comparison could be made between the natural symbiont and *R. solani*. Good germination and protocorm growth, developed with two strains of *R. solani* L10 and RS10 (symbiosis) while a few large protocorms survive in tubes inoculated with RS1 (partial symbiosis).

*Orchis foliosa* Soland. The natural symbiont of this orchid was not available but the endophyte of *Platanthera bifolia* produced the high percentage germination and rapid development of the protocorms comparable to the establishment of a mycorrhizal condition. The response of the seed to *R. solani,* L10, was similar (symbiosis) but with strains RS1 and RS10 only a few protocorms survive in each tube (partial symbiosis).

*Coeloglossum viride* (L.) Hartm. Partial symbiosis is recorded with two strains of *R. solani* (L10 and RS10) and symbiosis with the fungus isolated from the roots. On comparison, cultures with the pathogen show lower percentage germination, slower growth, and, after 10 weeks, fewer surviving protocorms than the cultures inoculated with the endophyte from the orchid.

*Corallorhiza trifida* Chatel. No strain of *R. solani* stimulated the seed of this orchid. This is not surprising as the natural endophyte of the orchid consists of sterile hyphae with clamp connections and is probably in no way related to the Rhizoctonia group of fungi. Seed germination with the endophyte has been

recorded on an enriched substrate (Downie, 1943), but as the fungus was no longer available in the laboratory no record could be made of the action of the endophyte on the impoverished media used above.

*Goodyera repens* (L.) R. Br. Partial symbiosis occurs with *R. solani* strains L10 and RS10, and symbiosis with the fungus isolated from the roots. The action of the other strains of the pathogen on the seed could not be recorded as the 1958 seed showed low viability as evidenced by asymbiotic germination. In 1957 few plants flowered and little seed was available, but that obtained had high viability. Trial experiments last year with this seed and some of the strains of *R. solani* (including L10 but not RS10) yielded similar results to those recorded above. The percentage germination and initial growth obtained with L10 compared favourably with the cultures containing the natural endophyte *Rhizoctonia goodyerae-repentis* but after a few weeks the protocorms were gradually killed off until only two or three survived. The survivors were maintained in culture for six months but their growth lagged considerably behind that of seedlings with the natural endophyte. At the end of the six months period the protocorms were surface sterilised and the fungus was re-isolated. On comparing the strain L10 before and after passage through the orchid no change could be observed.

*Gymnadenia conopsea* (L.) R. Br. Partial symbiosis was recorded with *R. solani* RS10 and it was only with this fungus that sizeable protocorms developed. The natural endophyte produced only slight stimulation. The basic substrates used in the experiments were probably unsuitable for this orchid.

*Leucorchis albida* (L.) Schur. No germination occurred in any of the cultures.

*Listera ovata* (L.) R. Br. Germination was obtained only with the natural endophyte of the orchid. This fungus is a species of *Rhizoctonia* with much finer hyphae than other orchid endophytes and is probably specific for the germination of *L. ovata* seed.

*Neottia nidus-avis* (L.) L. C. Rich. No symbiont of this orchid was available and none of the strains of *R. solani* introduced into the seed culture induced germination. In 1926 Wolff isolated a fungus from the roots of the orchid which he called *R. neottiae*. The latter has the morphological characteristics and the measurements of *R. solani*. Burgeff (1936) did not succeed

in stimulating germination with *R. neottiae* and it is debatable whether the effective symbiont has been isolated.

*Vanda tricolor* × *V. suavis.* Through the courtesy of Dr. H. R. Fletcher of the Royal Botanic Garden, Edinburgh, a capsule of Vanda derived from the above cross was made available. As the symbionts of the host plants were not obtainable the endophyte of *P. bifolia* was substituted. Partial symbiosis (only one protocorm surviving to give a green plantlet) occurred with this fungus, and an apparent symbiosis resulted from the association of the seed with *R. solani,* RS10. This experiment was set up in April 1958 and the single surviving plantlet with the endophyte of *P. bifolia* as well as the many plantlets in symbiosis with RS10 are still growing well. Without comparable seedlings stimulated with the natural symbiont, the relative growth rate of these with the *R. solani* seedlings cannot be estimated but the fact remains that a strain of *R. solani* isolated from rice plants proves a successful associate of this hybrid orchid.

## DISCUSSION.

Having shown in a previous publication that the seed of *O. purpurella* accepts the pathogen *R. solani* as a symbiont, the author decided to subject the seed of ten other orchids to similar tests. Six of these were found to react favourably with one or more of the experimental strains of the fungus, while the remaining orchids were either parasitised or uninvaded. Three of the unstimulated orchids are known to be specific with regard to their associated endophyte and the substrate requirements of the fourth (*L. albida*) have not so far been determined.

The natural associate of only two of the six stimulated orchids was available, and so interest centres around *Coeloglossum viride* and *Goodyera repens,* where the comparative growth effects of the symbiont and the pathogen could be studied. The symbionts of these two orchids are very similar, showing mycelium creamy-white in colour with encrusted sclerotial areas and hyphal diameter 4-5$\mu$. Thus they differ markedly in colour and hyphal dimensions from the majority of strains of *R. solani.* It was, therefore, surprising to find both orchids stimulated by such a diverse fungus. The growth induced by *R. solani* is much less and the association more unbalanced than with their respective endophytes but the fact remains that a few of the embryos of

both species can control the invasion of the pathogen and benefit to some extent by the result.

Further data will have to be accumulated before any generalisation can be made but the series of interactions between strains of *R. solani* and orchid seed, as noted above, opens a wide field for further investigation.

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## NOTES ON THE SCOTTISH FLORA.

### Hypochaeris glabra L. in Fife.

In Scotland *Hypochaeris glabra* is known only from a few scattered localities where it seems to occur most frequently as a casual. It has recently been rediscovered at Tentsmuir, Fife, in an entirely new habitat. The original record was made by Dr. Wilson of Edinburgh in June, 1932 (Herb. Royal Botanic Garden, Edinburgh), and the locality—described as a "sandy tract near Leuchars"—was outside the boundary of the present Nature Reserve. This locality has since been afforested, and the plant has become extinct.

In August, 1958, Mr. Ellis Crapper of Tayport and Mr. L. H. Fullerton (the Honorary Warden of the Reserve) discovered a new colony of *H. glabra* inside the Reserve. The plants are growing in an accretion dune formation which has been building-up seawards of a row of defensive concrete blocks during the past twenty years, since afforestation of the inshore area began. The plants are scattered over a few square yards surrounding a low sand-hummock on the flat dunes in an open community containing *Ammophila arenaria, Elymus arenarius, Festuca rubra, Filago minima, Hypochaeris glabra* and *H. radicata, Atriplex hastata* and *Sonchus asper.*

As a result of the proximity of *H. glabra* and *H. radicata* it is possible that hybridisation may occur.

R. B. Knox.

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### Saxifraga rivularis L.

This rare saxifrage is most commonly found on the higher mountains of Scotland growing among wet rocks at an altitude of 3,000-4,000 ft. It may be of interest, however, to record the occurrence of the plant in flower at a considerably lower altitude (about 2,600 ft.) in the Lairig Ghru Pass of the Cairngorms.

A. H. Sommerville.

### Umbilicus rupestris (Salisb.) Dandy.

*Umbilicus rupestris* is known in Britain to have a predominantly western distribution. In Scotland it is recorded only from the south-west and from the mid Inner Hebrides, but a record has now been made of its occurrence in eastern Scotland. South of Aberdeen, in Kincardineshire, a few plants are to be found growing on an old wall by the roadside. This appears to be a first record of the species for V.-C. 91 although the plant has long been known to local naturalists.

A. H. Sommerville.

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### Rorippa sylvestris (L.) Besser.

*Rorippa sylvestris* seems to be extending its range northwards. It has been located by the River Dee near Aberdeen by Dr. N. Robson and by Mr. G. Reid and has been collected in the vicinity of Culter by Dr. E. W. Fenton. It may now therefore be recorded for Kincardine (V.-C. 91) and S. Aberdeen (V.-C. 92). Previously the plant was only known to extend as far north as Angus in eastern Scotland.

A. H. Sommerville.

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### Cicerbita alpina (L.) Wallr. in Glen Callater.

To the account of *Cicerbita alpina* in the Glens of Doll, Canness and Caenlochan, and on Lochnagar (Roger, 1943), there may be added a note on its other station, at the head of Glen Callater. An early record of the plant in this last locality appears in Sowerby (1866), and probably refers to the colony described below.

This one growth is particularly fine, occupying an area of approximately 6 × 2 metres on a broad, slanting shelf of the north-facing crags at about 2,800 ft. Here, on 31st July, 1958, about 200 plants of *Cicerbita* were coming into flower. The shade cast by this dense mass is such that few other plants can compete and the associates grow mainly around its edges, though there is a patchy undergrowth of mosses. The tall herbs so typically found on mountain cliff-ledges are represented by the following: *Sedum rosea, Geranium sylvaticum, Alchemilla glabra, Rumex acetosa, Solidago virgaurea, Saussurea alpina, Oxyria digyna.* A

varied show of ferns, mainly on the outer side of the ledge, includes a luxuriant growth of *Athyrium alpestre, Thelypteris dryopteris, T. phegopteris* and *Dryopteris austriaca.* To these are added a more prosaic assortment of species such as *Luzula sylvatica, Deschampsia caespitosa, D. flexuosa, Galium hercynicum, Oxalis acetosella* and *Vaccinium myrtillus,* whilst the moss layer contains *Hylocomium splendens, Rhytidiadelphus loreus, R. squarrosus, Thuidium tamariscinum, Plagiothecium undulatum, Dicranum majus* and *Polytrichum commune.* The whole forms a community characteristic of sub-alpine birch and willow scrub in Scandinavia, but in Scotland banished to cliff-ledges. This particular shelf, somewhat awkward of access, is completely protected from the attentions of sheep, deer and goats.

The rock is syenite, and whilst the mull-humus soil of the *Cicerbita* ledge is poorer than those of the calcareous schists nearby, it is somewhat enriched by the drip of water from material containing some bases. The presence of *Saussurea* and *Oxyria* at the inner side of the ledge, where flushing is strongest, would indicate a moderately good soil, so that the Alpine Sow-thistle may be regarded as a tolerant rather than a calcifuge species (*cf.* Raven and Walters, 1956).

References.

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Derek A. Ratcliffe.

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## Potentilla crantzii (Crantz) Beck in the Stewartry of Kirkcudbright (V.-C. 73).

In July 1956, *Potentilla crantzii* was found growing sparingly on shattered cliffs of calcareous shale between 1,100 and 1,600 ft. in the Lamachan Hill group, a few miles west of Clatteringshaws Reservoir. The only other stations for this plant in Southern Scotland are on the Moffat Hills in Dumfriesshire. On the same range of crag, *Thalictrum alpinum* is abundant in flushed places, and the rocks have *Asplenium viride, Galium boreale, Sedum rosea, Arabis hirsuta* and *Vicia orobus. Cirsium heterophyllum,*

a rather rare plant in Galloway, grows on at least one broad shelf, and *Eriophorum latifolium* is frequent in calcareous flushes not far below the crags. This is probably the most extensive exposure of calcareous rock in the whole of the Galloway Hills, but the rather low altitude accounts for the small number of mountain plants. The district as a whole has a very poor montane flora, due partly to the scarcity of base-rich rocks, and the *Potentilla* locality is one of its richest places.

DEREK A. RATCLIFFE.

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## CETERACH OFFICINARUM DC. IN EAST SCOTLAND.

*Ceterach officinarum*, the rusty-back or scale fern, is not common in Scotland. Clapham, Tutin and Warburg in their *Flora of the British Isles* (1952) refer to it as being "rather common in south and west England, Wales and Ireland" but "very local" in eastern England and absent from some counties. In Scotland they report it as being "very local" and mention certain centres, noting that it is recorded only from Berwick for the south-east. I am indebted to Dr. H. R. Fletcher and Mr. D. M. Henderson of the Royal Botanic Garden, Edinburgh, for informing me that apart from the south-west counties (Dumfriesshire, etc.) where it is fairly widespread, it has been found in Berwick, Stirling, Fife and Kinross, Mid Perth, East Perth, Argyll, Dunbartonshire, Clyde Islands and South and Mid Ebudes. In the herbarium they have specimens from Perthshire, Dunbartonshire, Berwickshire and Wigtownshire.

A few years ago I re-visited one of the Stirlingshire sites in the Blane Valley and was distressed to find how it was threatened by building operations. It was therefore with particular pleasure that I came on a few well-established groups of this lovely, and interesting, fern within a mile of the Kirkton of Skene, Aberdeenshire (V.-C. 92). A few months later I also found a few younger plants on a garden wall in the neighbourhood of Stonehaven (V.-C. 91).

The occurrence of plants over fifty miles north of the nearest known colony, in the Carse of Gowrie, raises the interesting questions of (a) how the two new sites arose; and, (b) are there any other northern colonies?

Casting my mind back to the beginning of the century, I am reminded of a discussion where the late Professor J. H. Trail was questioned as to how Wall Rue could be best established in old walls. He pleaded with his hearers not to try to transplant specimens, but to lay fertile fronds with ripe spores on the desired spots. Remembering that both of the new colonies have arisen in localities near where enthusiastic amateur gardeners once dwelt, I cannot help wondering whether these plants have arisen in such a manner.

K. W. Braid.

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### Saponaria officinalis L. in Aberdeenshire.

Soapwort, *Saponaria officinalis* L., is not common in Aberdeenshire. Dr. E. Wyllie Fenton and I came upon a nice patch of it in what, presumably, had been the garden of a ruined croft some 500 yards north of the Aberdeen-Tarland road between the tenth and eleventh milestones. In October, when we first saw it, all the few remaining flowers examined were double.

K. W. Braid.

## Report of the Cryptogamic Section, 1958.

By D. M. Henderson.

The annual autumn foray was held in the Edzell district on 13th and 14th September, with headquarters and a working room in the Central Hotel. Owing to a spell of dry weather the pine wood south of the town presented little of interest, but a small mixed deciduous wood at Little Brechin gave good collections on Saturday, 13th. As is customary, the late afternoons and evenings were spent examining the day's finds. On Sunday interesting beech woods in the grounds of The Burn yielded representative collections. The most striking finds were fine groups of *Coprinus narcoticus* and *Aleuria aurantia* on old potato pit refuse—the *Aleuria* up to 24 cm. in diameter. The rather uncommon *Boletus calopus* was a feature of the beechwood floor. The meeting was attended by nine members.

### List of Fungi Collected.

(Agarics according to Pearson & Dennis: Check list, unless otherwise indicated. Rust fungi according to Wilson & Bisby: Check list.) (a) Edzell pine wood. (b) Mixed wood Little Brechin. (c) Beech wood at The Burn, Edzell.

#### Agaricales.

Amanita citrina, c; muscaria, a, b; rubescens, a, b, c.

Amanitopsis fulva, a, b, c; inaurata, a, b.

Armillaria mucida, b, c.

Tricholoma ustale, c; portentosum, b; rutilans, a, c; virgatum, c.

Clitocybe umbonata, a; clavipes, a.

Laccaria laccata, a, b; proxima var. bicolor, a; amethystina, b, c.

Mycena galopus, a, c; sanquinolenta, a; epipterygia, b; alcalina, a, c.

Collybia radicata, c; cirrata, a; distorta, c; butyracea, a; palustris, b.

Marasmius peronatus, c; dryophilus, a; androsaceus, a, c.

Omphalia umbellifera, c; integrella, b.

Nyctalis parasitica, a.

Lactarius torminosus, b; plumbeus, b; vietus, a, b, c; blennius, a, b, c; quietus, b; rufus, a; decipiens Quelet, c.

Russula nigricans, a, c; adusta, a; cyanoxantha, c; heterophylla, c; vesca, c; laurocerasi, c; emetica, a; mairei, b, c; sanguinea, a; drimeia, a; fellea, b, c; badia, a; ochroleuca, a, b, c; xerampelina, a; claroflava, a, b; caerulea, a.

Cantharellus cibarius, a, b, c; tubaeformis, b, c.
Pluteus cervinus, c.
Entoloma nidorosum, b.
Nolanea cetrata, a.
Eccilia rhodocylix, a, b.
Pholiota flammans, a; mutabilis, b; caperata, a.
Flammula scamba, b; penetrans, a.
Naucoria bohemica, b.
Tubaria conspersa, b; paludosa, b.
Cortinarius delibutus, b; pseudosalor Lange, c; bolaris, b, c; kauffmannianus Henry, c; tabularis, a, b; cinnamomeus, a; semisanguineus, a; cinnamomeo-badius Henry, c; lepidopus, a; armillatus, a, b; gentilis, a; evernius, a; torvus, c; flexipes, b, c; rigidus, b, c; scandens, b; acutus, b; fasciatus, a; adalberti Favre, a.
Inocybe geophylla, c; umbrina, c; decipientioides, b.
Paxillus involutus, a, b, c; atrotomentosus, c.
Stropharia aeruginosa, c.
Hypholoma fasciculare, a, b, c; capnoides, a; dispersum, b.
Coprinus cineratus Quelet, a; narcoticus, c.
Boletus reticulatus, c; erythropus, c; calopus, c; bovinus, a; variegatus, a; subtomentosus, a; badius, a; scaber, a, b; versipellis, b.

## Uredinales.

Coleosporium tussilaginis II on *Campanula rotundifolia* and *Euphrasia officinalis*, c.
Melampsora hypericorum II on *Hypericum pulchrum*, c.
Melampsoridium betulinum II on *Betula verrucosa*, a, c.
Milesia blechni II on *Blechnum spicant*, a; kriegeriana II on *Dryopteris spinulosa*.
Puccinia airae II on *Deschampsia caespitosa*, c; oblongata II, III, on *Luzula pilosa*, c; violae II, III, on *Viola canina*; annularis III on *Teucrium scorodonia*, c; holcina II on *Holcus mollis*, c.
Pucciniastrum epilobii II on *Chamaenerion angustifolium*, a, c.
Pucciniastrum goodyerae II on *Goodyera repens*, a.
Thekopsora vacciniorum II on *Vaccinium myrtillus*, a, c.

## Report of the Alpine Section, 1958.

By J. Grant Roger.

### Excursion to Lochan na Lairige, Perthshire.

(14th June 1958.)

This day-excursion from Edinburgh to the crags of Ben Lawers Schists on the west side of Lochan na Lairige was arranged mainly for the purpose of introducing students to the rich flora of such friable base-rich rocks here occurring at a comparatively low elevation and within easy reach by road. The party, consisting of 14 students and 12 others, ascended towards the crags from the south end of the Lochan (now enlarged to form a reservoir for the North of Scotland Hydro-Electric Board) and proceeded to explore the steep rocks and ledges ranging in altitude from about 2,000 ft. to 2,200 ft. On these the following species of vascular plants were noted:—*Agropyron donianum, Alchemilla alpina, A. glabra, Angelica sylvestris, Anthyllis vulneraria, Arabis hirsuta, Armeria maritima, Asplenium viride, A. trichomanes, Botrychium lunaria, Cerastium alpinum, Circium heterophyllum, Chamaepericlymenum suecicum, Cherleria sedoides, Cochlearia alpina, Cystopteris fragilis, Draba incana, Dryas octopetala, Epilobium alsinifolium, Erophila verna, Festuca vivipara, Galium boreale, Geranium lucidum, G. sylvatica, Geum rivale, Helictotrichon pratense, Heracleum sphondylium, Juncus biglumis, Listera ovata, Luzula spicata, L. sylvatica, Lycopodium alpinum, L. clavatum, L. selago, Oxyria digyna, Poa alpina, Polygonum vivaparum, Polystichum aculeatum, P. lonchitis, Pyrola rotundifolia, Rubus saxatilis, Salix arbuscula, S. reticulata, Saussurea alpina, Saxifraga aizoides, S. hypnoides, S. nivalis, S. oppositifolia, S. stellaris, Sedum rosea, Selaginella selaginoides, Sesleria caerulea, Silene acaulis, Sorbus aucuparia, Thalictrum alpinum, Thelypteris phegopteris, Tofieldia palustris, Trollius europaeus, Vaccinium uliginosum, Vicia sylvatica, Viola lutea* var. *amoena*, and *Woodsia alpina*.

Of the species mentioned above, *Listera ovata* and *Geranium lucidum* are noteworthy as occurring at over 2,000 ft., probably at their upper altitudinal limits in this region.

Prominent among the mosses present were *Ctenidium molluscum, Orthothecium rufescens, Rhytidium rugosum* and *Tortella tortuosa*—all characteristic of calcareous schists.

Fungi recorded by Mr. D. M. Henderson included:—*Phragmidium fragariastri*, on *Potentilla sterilis*, *Puccinia septentrionalis* on *Thalictrum alpinum*, and *Synchytrium aureum* on *Prunella vulgaris*; also the montane agarics—*Omphalina ericetorum* on peat banks at all levels, and *O. luteovitellina* on algae-covered peat at 2,200 ft.

MEETING AT TYNDRUM, 20TH-22ND JUNE 1958.

The purpose of this weekend field meeting centred on Tyndrum was to explore neighbouring mountain areas hitherto rarely visited by botanists. The party, which consisted of 21 in all, included 8 students of Edinburgh University Botany Department, travelled from Edinburgh on the evening of Friday, 20th June, and returned to Edinburgh on the evening of Sunday, 22nd June. During each field day comprehensive records of the vascular plants observed were made for the B.S.B.I.'s Distribution Maps Scheme.

On the 21st of June the whole day was spent on the Black Mount area west of Loch Bà, particularly on Meall à Bhuiridh (3,636 ft.), the highest mountain in this part of Argyll. Here granite and quartzose felspathic schists are prevalent, yielding acid and rather infertile soils compared with those derived from the schists of the Ben Lawers series found at Lochan na Lairige on 14th June.

On the lower moorlands between about 1,000 and 1,200 ft. the common species of vascular plants noted were:—*Calluna vulgaris*, *Carex demissa*, *C. echinata*, *C. nigra*, *C. pauciflora*, *C. rostrata*, *Drosera anglica*, *D. rotundifolia*, *Erica cinerea*, *E. tetralix*, *Eriophorum angustifolium*, *E. vaginatum*, *Genista anglica*, *Juncus effusus*, *J. squarrosus*, *Luzula multiflora*, *Molinia caerulea*, *Myrica gale*, *Narthecium ossifragum*, *Pedicularis palustris*, *P. sylvatica*, *Pinguicula vulgaris*, *Polygala serpyllifolia*, *Potentilla erecta*, *Salix aurita*, and *Trichophorum caespitosum*.

On the more heathy or grassy slopes from about 1,200 to 2,000 ft. the following were frequent:—*Achillea millefolium*, *Anemone nemorosa*, *Antennaria dioica*, *Anthoxanthum odoratum*, *Carex pilulifera*, *C. panicea*, *Cerastium vulgatum*, *Conopodium majus*, *Festuca ovina*, *Galium hercynicum*, *Lathyrus montanus*, *Lotus corniculatus*, *Lycopodium clavatum*, *Plantago lanceolata*, *Succisa pratensis*, *Trientalis europaea*, *Vaccinium myrtillus* and *V. vitis idaea*. *Crepis paludosa*, *Thelypteris dryopteris* and

*Equisetum sylvaticum* were found by burns, usually in some shade.

During the ascent over the *Calluna-Eriophorum* moors to the high shoulder of Meall à Bhuiridh, *Chamaepericlymenum suecicum* and *Rubus chamaemorus* were noted at 2,000 ft. Later, on exposed slopes from about 2,400 ft. upwards, *Loiseleuria procumbens* was found along *Lycopodium alpinum*, and from here up to the base of a series of steep rocks the following species were common locally:—*Alchemilla alpina, Armeria maritima, Carex bigelowii, Deschampsia caespitosa, Gnaphalium supinum, Nardus stricta, Sibbaldia procumbens, Silene acaulis* and *Thalictrum alpinum*. At 3,100 ft. *Caltha palustris, Chrysoplenium oppositifolium, Epilobium anagallidifolium, Eriphorum vaginatum, Tofieldia pusilla, Veronica serpyllifolia* spp. *humifusa* and *Viola palustris* grew near a spring by the base of east-facing granite cliffs.

In several places among the granite cliffs just mentioned, snow lay in patches of several yards and on the surrounding rocks, from 3,100 to about 3,300 ft., *Athyrium alpestre, Cochlearia alpina, Saussurea alpina, Thelypteris phegopteris* and *Trollius europaeus* occurred sparingly. *Campylopus atrovirens* was conspicuous on some of the wetter rocks.

The summit region of the mountain was approached along a craggy shoulder which sloped fairly gently to the north but fell steeply on the south side opposite Clach Leathad (3,602 ft.). On this, the highest part of Meall à Bhuiridh, from about 3,500 ft. towards the summit cairn the most prominent plants included *Alchemilla alpina, Carex bigelowii, Deschampsia caespitosa, Empetrum hermaphroditum, Festuca ovina, Gnaphalium supinum, Lycopodium selago, Oligotrichum hercynicum, Rhacomitrium lanuginosum, Salix herbacea* and *Vaccinium myrtillus*. The montane agaric, *Omphalina luteovitellina* was collected by Mr. Henderson at 3,500 ft. on Stob Ghabhar.

On 22nd June the hills immediately north-east of Tyndrum were visited, the party ascending from Auchtertyre towards Meall Buidhe (2,136 ft.) and Beinn Chaorach (2,655 ft.). The rocks underlying the prominent grassy slopes of these hills are schists of the Ben Lawers series but apart from the good crags on the east side of Beinn Chaorach the rocks are rarely exposed.

Bracken was found to be dominant over much of the pasture

land at and beyond Auchtertyre up to about 1,000 ft. On the pastures of the middle slopes (c. 1,000-2,000 ft.) of Beinn Chaorach, with southern aspect, the common grasses were *Anthoxanthum odoratum, Festuca ovina, F. rubra, Nardus stricta* and *Poa pratensis*; and in the same area the following species occurred —*Alchemilla alpina, Anemone nemorosa, Blechnum spicant, Carex pilulifera, Galium hercynicum, Juncus squarrosus, Leucorchis albida, Luzula multiflora, Lysimachia nemorum, Orchis ericetorum, Pedicularis sylvatica, Plantago lanceolata, Potentilla erecta, Ranunculus acris, Taraxacum officinale, Thalictrum alpinum, Thymus drucei* and *Vaccinium myrtillus.* Between 1,700 and 1,900 ft. on the south eastern side of the hill *Calluna vulgaris, Eriophorum angustifolium, E. vaginatum* and *Trichophorum caespitosum* were locally common.

Proceeding towards the rocky summit area of Beinn Chaorach the following species were noted as they appeared with advance in altitude—

2,000-2,200 ft.: *Carex dioica, Juncus triglumis, Saxifraga aizoides, S. oppositifolia, S. stellaris* and *Triglochin palustris.*

2,200-2,400 ft.: *Antennaria dioica, Campanula rotundifolia, Empetrum hermaphroditum, Luzula spicata, Lycopodium alpinum* and *Silene acaulis.* Over parts of this area *Vaccinium myrtillus* and *Alchemilla alpina* were co-dominant.

2,400-2,650 ft.: *Carex bigelowii, Cerastium vulgatum, Gnaphalium supinum, Hieracium pilosella, Loiseleuria procumbens, Polygonum viviparum, Potentilla erecta, Salix herbacea* and *Vaccinium vitis-idaea.*

On the steep, moist crags between 2,400 and 2,600 ft. on the east side of Beinn Chaorach many species favouring the Ben Lawers Schists were noted, including—*Adoxa moschatellina, Alchemilla glabra, Carex capillaris, Chrysosplenium oppositifolium, Cochlearia alpina, Cystopteris fragilis, Epilobium anagallidifolium, Polygonum viviparum, Mercurialis perennis, Polystichum lonchitis, Oxyria digyna, Saxifraga aizoides, S. hypnoides, S. nivalis, S. oppositifolia* and *Selaginella selaginoides.*

Of fungi on the higher parts of Beinn Chaorach two agarics, *Omphalia sphagnicola* and *Stropharia semiglobata* were collected at 2,300 ft. while at about the same elevation the aecidia of *Puccinia septentrionalis* were found on *Thalictrum alpinum.*

## Committee for the Study of the Scottish Flora.

*Miss U. K. Duncan
Mrs. F. M. Elder (Field Secretary)
*D. M. Henderson
R. Mackechnie (Chairman)
*Professor J. R. Matthews
†B. W. Ribbons (Secretary)
†J. G. Roger
†G. Taylor

*appointed by the Botanical Society of Edinburgh.
†appointed by the Botanical Society of the British Isles.

*Fourth Annual Report to 31st December 1958.*

The Committee has met twice (at Edinburgh in March and at Inverness in October) and has held four Exhibition Meetings (at the University of Aberdeen, Department of Botany, by permission of Professor J. R. Matthews on 7th March; at Gracefield, Dumfries, by arrangement with the Dumfriesshire and Galloway Natural History and Antiquarian Society on 26th April; at the Royal Academy, Inverness, by permission of the Director of Education on 18th October; and at the University of Glasgow, Department of Botany by permission of Professor J. Walton on 8th November. Four Field Meetings have been held (at Perth, 16th-19th May, led by Miss E. P. Beattie; on the Island of Bute, 23rd-26th May, led by the Chairman; on the Isle of Skye, 5th-12th July, led by Miss C. W. Muirhead; and at Lairg, 12th-19th July, led by Ian C. Hedge).

Most of the work at the Field Meetings was again devoted to recording for the Distribution Maps Scheme. Six members and friends attended at Perth, 27 at Bute, 11 at Skye, and 8 at Lairg. Reports of these Meetings will appear in *Proc. Bot. Soc. British Isles.*

The Inverness Exhibition Meeting planned for March was postponed until October at the request of the local botanists.

At the Aberdeen meeting, 18 local botanists attended. Professor Matthews drew attention to the fact that almost a century had elapsed since the publication of *The Botanist's Guide to the Counties of Aberdeen, Banff and Kincardine* by George Dickie, and suggested that an effort should be made to revise this local flora and bring it up to date. It seemed desirable to start with

Kincardineshire, with a view to preparing an account of the flora of this county in the first instance. The methods to be adopted in making records of the flora were outlined and emphasis was laid on the necessity for voucher specimens of all critical species to be deposited in the Herbarium of Aberdeen University.

Mrs. A. H. Sommerville then spoke of the County of Kincardine, from both a geographical and a botanical point of view, illustrating her talk by coloured lantern slides, of individual species or of ecological interest. Herbarium specimens of Kincardineshire plants were also exhibited, including *Astragalus hypoglottis, Sedum villosum, Chrysosplenium alternifolium, Ligusticum scoticum, Meum athamanticum, Artemisia maritima, Centaurium littorale, Mertensia maritima, Littorella lacustris* and *Paris quadrifolia.* Special attention was drawn to a specimen of *Linnaea borealis* collected by Dr. Knight of Aberdeen in 1812 from the Woods of Inglismaldie, Fettercairn, this being the locality where the species was first discovered as a native of Scotland by Professor J. Beattie in 1795. Other exhibits of note included *Cystopteris dickieana* collected by J. Roy in 1871 from the only known British locality at Cove Bay, and herbarium sheets of *Lycopodium alpinum, L. clavatum* and *L. selago* collected over 100 years ago by P. H. MacGillivray near the Bay of Nigg at an altitude of 250 ft. above sea level.

Mrs. Sommerville also referred to the Distribution Maps Scheme and outlined the work remaining to be done in the North-East of Scotland. To accomplish this, it was decided to arrange weekly field meetings during the months of May and June.

Dr. C. H. Gimingham contributed a brief account of the maritime flora of St. Cyrus, a particularly rich area of Kincardineshire long known to Aberdeen botanists and the centre of much ecological work carried out in recent years by the Botany Department of the University. The richness of the flora was ascribed to a favourable local climate, the relatively high base-status of the substratum deriving from the andesitic lavas of which the cliffs are composed, and a wide variety of habitats supporting cliff, sand-dune and salt-marsh communities. Lantern slides were used to illustrate these communities together with numerous specimens of plants representative of the counties, including *Anchusa sempervirens, Astragalus glycyphyllos, Campanula glomerata, Carlina vulgaris, Echium vulgare, Eupatorium canna-*

*binum, Filago germanica, Trifolium scabrum, Hyoscyamus niger, Trifolium striatum, Silene nutans* and *Vicia sylvatica* from the cliffs, and *Astragalus danicus, Dianthus deltoides, Geranium sanguineum, Origanum vulgare* and *Saxifraga granulata* from dune communities.

Maps and photographs of the area were also exhibited and reference was made to the recent disappearance of *Salicornia* sp. from the salt-marsh and the re-appearance of *Reseda luteola* and *Malva sylvestris,* recently found by Mr. Alastair Henderson.

The attendance at the Dumfries meeting was about 30. The Botanical Society of the British Isles, the Botanical Society of Edinburgh and the Scottish Field Studies Association all showed exhibits illustrating their work and the services provided for their members. There were also the following exhibits: Maps to show the progress of the Distribution Maps Scheme in Scotland (F. H. Perring and E. P. Beattie), Herbarium Specimens of plants from Switzerland having Scottish connections (the Chairman), Some Common Rust and Smut Fungi (D. M. Henderson), Arctic-Alpine Plants to be sought in Britain (P. S. Green), British Watercresses (P. S. Green), Plants representative of South-west Scotland mainly from the Dumfriesshire and Galloway Natural History and Antiquarian Society's Herbarium (H. Milne-Redhead), and a collection of early local plant lists, botanical books, and portraits and biographical material of authors (A. E. Tuckell, Curator of the Burgh Museum, Dumfries).

The Secretary spoke about the work of the Committee, the Chairman lectured on the Preparation of Voucher Material and Mr. J. Grant Roger gave an illustrated address on Conserving the Scottish Flora.

Some 50 persons attended at Inverness to hear a masterly account of "The Vanished Scottish Flora" by Dr. J. B. Simpson of Nairn. The lecture was illustrated by photographs, including some remarkably convincing studies of pollen from past floras shown together with modern pollen grains. The following exhibits were shown: Arctic plants not yet found in Britain (P. S. Green); Distribution maps of *Leontodon hispidus* and *L. leysseri* and of *Quercus robur* and *Q. petraea* in North Britain (B.S.B.I. Maps Scheme); Local Mosses and Liverworts (Inverness Botany Group); Grasses collected in Inverness-shire, Easter Ross, Moray, and Nairn (U. K. Duncan); Living *Pilularia globulifera*

and *Corydalis claviculata* from Nairn (J. G. Roger); Ecological groups of the larger fungi (D. M. Henderson); Living specimens and photographs of British species of *Leontodon* and *Hypochaeris* (R. Knox); *Vicia sepium* var. *ochroleuca* from Inverness and *Acaena anserinifolia* from Blackfold, Dochfour, Inverness (E. Stollery).

In Glasgow the attendance was 36, and the following exhibits were shown: *Koenigia islandica* on the Storr, Skye (D. Ratcliffe); Specimens and transparencies of Scottish rare plants (A. Slack): Specimens of *Cladonia, Peltigera* spp. and other Scottish lichens (G. D. Scott); the Maps Scheme exhibit on *Leontodon* and *Quercus*; Interesting plants from the Skye field meeting (U. K. Duncan); New County Records and some rare Scottish Plants (A. M. Stirling); Some recent plant records from the Hebrides, including Skye, Barra and Gigha (C. W. Muirhead and P. H. Davis); and the Chairman's exhibit of Scottish plants. After tea, lantern slides were shown by Messrs. E. H. and D. J. McCosh (Rare Scottish Plants); Dr. G. D. Scott (Some Scottish Lichen species); the Secretary (Plants seen on the 1958 field meetings—including *Betula nana, Vicia orobus, Koenigia, Scrophularia aquatica* and *Eriocaulon*); Dr. D. Ratcliffe (*Koenigia*), and Mr. A. M. Stirling (Rare Plants).

Mr. B. L. Burtt resigned from the Committee at the beginning of the year and Mrs. F. M. Elder was appointed as a co-opted member in his place. Mr. R. Mackechnie was elected Chairman and Mrs. Elder Field Secretary.

The accounts showed a surplus of £2 10s. 10d. for the year 1957 and hence no claim was made upon either of the sponsoring Societies.

During the year the Committee has had the arrangements for the 1959 B.S.B.I. Annual General Meeting and also the Society's proposals for a regional reorganisation under consideration. Attention has also been given to the possibility of promoting botanical investigations in various parts of Scotland.

Once again it is a pleasure to express grateful thanks to all those who have given freely of their time and energy to make possible the various activities arranged by the Committee; in particular much is owed to the efforts of Mr. Burtt, Chairman of the Committee from its origin in 1955 until his departure to Pakistan early this year.

B. W. Ribbons, *Hon. Secretary.*

# BOTANICAL RESEARCH IN SCOTLAND.

Although almost all Research Institutes, Colleges and University Departments issue Annual Reports giving details of completed research and of work in progress, it is not always easy for individual botanists to keep informed about the general progress of botanical research from year to year. It is even more difficult for individuals to keep up to date with original papers published in a wide range of botanical journals, yet there are many who are anxious to know something of the botanical investigations in progress throughout Scotland.

The Council of the Botanical Society of Edinburgh has therefore gathered together brief reports from a number of centres of botanical activity in Scotland in the hope that these summaries will serve to indicate at least the type of botanical work being attempted throughout the country.

We wish to express our thanks to all the individuals who have co-operated by providing surveys of the work with which they are concerned.

## I. Research Institutes.

### Department of Agriculture for Scotland.

### East Craigs, Corstorphine, Edinburgh.

*Crop Improvement*: (1) Cereals.—Studies are continuing on the varietal characters and on cropping potentials of all varieties of oats at present admitted to the official Oat Certification Scheme and of a number of new oat varieties; similar studies are also carried out on barley varieties likely to be involved in the new official Barley Certification Scheme. Studies have been made on grain: straw ratios of oat varieties grown in variety trials for the last twenty years or so in Scotland, on the effect of seed-rate on the development of the oat plant and on the effect of origin of the seed sown on the resulting oat crop.

(2) Herbage Crops.—Spaced-plant grass trials over the period 1956-58 have been completed but further trials of new strains in 1959-61 have been started. Grass reproducibility trials are being carried out in conjunction with the National Institute of Agricultural Botany at Cambridge.

*Seed Testing.*—Methods to improve the tests for germination of brassicas, clovers, cereals and pulses have been under investigation, with promising results. Comparative tests have been co-ordinated for the International Seed Testing Association in collaboration with North European seed testing stations for trefoil seed and other collaborative tests for other seeds have also been carried out with the same stations.

*Potatoes.*—Trials to assess the culinary and commercial attributes of new potato seedlings are conducted with the object of registering those which achieve certain standards, and for this purpose research into improving the testing techniques is continuing. Other investigations include the testing of varieties for their virus susceptibility and for improving the testing techniques used for that purpose, dormancy in potato tubers, the effect of storage conditions on sprout growth and botanical identification characteristics of old and new varieties both in the foliage and tuber stage.

*Crop Protection*: (1) Potatoes.—Studies were made on the nature, cause and distribution of virus-like symptoms in potato crops in many districts of Scotland and on better methods for the quicker identification of the more difficult virus types. More definitive work was carried out on the soil-borne types of virus, on veinal necrosis, on virus S and on chemical control of leaf roll.

A complete re-examination has been made of the pathogens involved in potato Black Leg, their survival in soil and on and in the tuber, and on the mechanical transmission of the disease and its control. Experiments are continuing on the control of *Rhizoctonia solani* on tubers. Further research has been undertaken on Gangrene (*Phoma foveata* and *P. tuberosa*) and Skin Spot (*Cospora pustulans*).

(2) Other Crops.—Studies were made of lettuce mosaic with infected field crops and on the best technique for determining its presence in lettuce seed.

*Seed Pathology.*—Seed surveys in wheat, oats and barley have been completed and published. Further surveys will be carried out in certain pulse, vegetables and grass seeds but for many of these new techniques are required.

## The Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian.

*Disease resistance*: (1) Potato blight (*Phytophthora infestans*). —The wide distribution of most of the known races of the fungus indicates that resistance through hypersensitivity, "field immunity" will eventually break down, and consequently a combination of hypersensitivity and "field resistance", so long obscured in seedlings bred from *Solanum demissum* by the presence of R genes, is now the aim. Although additional R genes controlling hypersensitivity are being sought, work is largely concentrated on the inheritance of "field resistance" derived from *S. demissum*, *S. stoloniferum* and other species. Problems relating to the origin, distribution, and classification of physiological forms of *P. infestans* are also being studied.

(2) Potato root eelworm (*Heterodera rostochiensis*).—The finding of eelworm populations that are capable of breaking down the resistance characteristic of the potato clone C.P.C.1673 (*S. tuberosum* subsp. *andigena*) has led to a search for other sources of resistance. Resistance of one kind or another has now been found in *S. tuberosum* subsp. *andigena*, *S. famatinae*, *S. demissum*, *S. multidissectum*, *S. neohawkesii*, *S. megistacrolobum*, *S. raphanifolium*, *S. sanctae-rosae*, *S. vernei* and *S. infundibuliforme* and the inheritance of these resistances is being studied. *S. vernei* is of particular interest, for its resistance remains effective against the eelworm populations known to overcome resistance in C.P.C.1673. The initial difficulty of hybridising diploid *S. vernei* with tetraploid cultivars has been surmounted by chromosome doubling in certain *S. vernei* clones.

(3) Oat stem eelworm (*Ditylenchus dipsaci*).—A rapid laboratory test has speeded up the detection of resistance which on analysis appears to take a variety of forms. The nature and inheritance of these resistances are being examined.

(4) Potato viruses.—Various means of attaining resistance to potato viruses are under investigation, the current problem being to transfer attributes of resistance value from wild species to cultivated forms of potato.

(5) Grass and cereal viruses.—An assessment of the importance of these viruses to Scottish agriculture is the immediate aim.

*The ecotype concept*: The circumstances occasioning ecotypic and topotypic population differentiation are being examined with the emphasis now shifted from a single habitat component to communities of species, special attention being given to communities comprising *Agrostis* and *Festuca* and to detailed studies of the *Agrostis canina-tenuis* and the *Festuca ovina* complexes. The occurrence of wide-spreading plants is being used to provide evidence of the ecological tolerances of *individual genotypes,* while lead tolerances are employed in the study of *population* responses to environmental selection. The indications are that lead-resistant populations fall into three groups of plants showing high, medium and low tolerances and that each population usually consists of only a single type.

*Synthesis of new plant types*: Inter- and intra-specific hybridisation within the genus *Brassica* is being explored as a means of obtaining novel types. The synthesis of rape-like forms of *B. napus* by the production of alloploid hybrids of *B. oleracea* × *B. rapa* or other ten-chromosome species and the exploitation of the wide range of compatible forms within *B. oleracea* itself gives scope for recombination of characteristics.

## The Scottish Horticultural Research Institute, Mylnefield, Invergowrie.

Many investigations at horticultural research centres have a strong botanical bias and work at Mylnefield is no exception. This brief review does not present detailed results of work in progress at the Scottish Horticultural Research Institute but outlines some of the investigations which may be of particular interest to botanists. Such investigations lie mainly in the Departments of Pomology (horticultural botany), Crop Physiology, Vegetable Culture and Genetics. Investigations in the Departments of Virology and Plant Pathology also frequently draw heavily upon well-recognised botanical knowledge and techniques.

The work of the Pomology Department may quite properly be described as horticultural botany. This Department maintains variety collections and carries out variety, cultural, and manurial trials in those horticultural crop plants in which we are interested, viz. apples, raspberries and black currants. It is also developing

species collections of *Rubus* and *Ribes*. This involves a fair amount of taxonomy and is a necessary background to the vigorous raspberry and strawberry breeding programmes being carried out in collaboration with Genetics. An apple variety collection, comprising almost 700 named varieties including all those of Scottish origin known to us and many of the newer varieties from North America, Scandinavia and Northern Europe, is already established and is being extended each year. Variety recognition and performance is an important aspect of Pomology and this can only be learnt by practical observation.

Raspberry and black currant breeding programmes are major projects in the Pomology Department. The raspberry breeding programme which employs the 'selfing-down technique' aims at producing (*a*) varieties with improved canning and quick-freezing qualities and (*b*) varieties resistant or immune to infection by the soil-borne viruses known to occur in certain parts of Scotland and elsewhere. Secondary problems such as delayed germination and partial sterility arise in this work and must be dealt with as the main programme proceeds.

Another important and rapidly developing project is the use of chemicals as selective herbicides with raspberries and strawberries in particular. Some important aspects of the selective action of some of these chemicals have been observed and the use of two or more chemicals in combination looks more promising than the use of individual chemicals alone. The possible soil sterilising effect of these chemicals applied to a particular soil for a number of years in succession, such as occurs in the treatment of raspberry rows, cannot be overlooked. This kind of work must obviously employ botanical and biochemical techniques if it is to proceed on a scientific rather than an *ad hoc* basis.

The Crop Physiology Department has two main objectives. The first is an analysis of the climatic complex of Scotland in an effort to determine the relative importance of such factors as daylength, light intensity and quality, and day and night temperatures. Lack of reasonably reliable and cheap light-integrating equipment has proved a severe handicap to this work and much time has been spent on developing such equipment, but the light integrators finally evolved and now undergoing test should have a wide application in Crop Physiology work. Using these instru-

ments along with the growth analysis technique of Blackman the effect of light intensity and duration using Sunflower and Field bean was studied in 1956-7. It proved impossible, however, to disentangle the temperature effect from the light effect. A specially designed piece of equipment has therefore been built in order to study temperature as an individual factor under the naturally occurring light conditions at Mylnefield. *Lemna* is being used as the test plant. At present this work is a little remote from immediate horticultural practice but the apparatus and techniques are of particular interest to botanists and it is necessary to undertake such work as a preliminary to the development of improved practice.

The other line of work in Crop Physiology is the study of the effect of environment on flower and runner initiation and development in the strawberry. For this work, special growth cabinets have been designed and built to take advantage of the fact that the strawberry offers the opportunity of obtaining identical plants which can remain connected by their stolon. The growth cabinets enable separate plants of each pair to be put under completely different environment conditions. A practical outcome of this work is the possibility of lifting strawberry plants during the dormant season and maintaining them under deep-freeze conditions for some three or four months so that they can be planted in the field during June and July when current year's runners are not available. Another practical aspect of Crop Physiology work is the use of maleic hydrazide to retard or inhibit runner production in the strawberry under field conditions. Sufficient promise is already shown and it is now necessary to determine both the best time of application and concentration of active material.

The main objectives of the Vegetable Culture Department is to extend the range of vegetables which can be relied upon to produce economic crops in Scotland particularly during the period November-March. This project involves (*a*) the testing under Scottish conditions of varieties of a number of crop plants and (*b*) the initiation of breeding programmes to produce new varieties. In 1958 about 50 varieties of French Bean from England, France, Scandinavia, Holland, Germany and Jugoslavia which combine a number of desirable characters were grown at Mylnefield and while some of them were obviously unsuited to our conditions others showed remarkable promise. These latter, while

not completely suitable as varieties, provide breeding material. Furthermore, it has been shown that while the English varieties of Spinach normally run to seed when grown in Scotland, other varieties, particularly those of Scandinavian origin, will produce very good yields indeed.

The second important line of work in Vegetable Culture is investigation into the problem of bolting or premature flowering in brassicas, carrots and other crops. This is related to the climatic complex and the only practical method of overcoming the difficulty is to understand the physiologic and genetic basis of the phenomena as a preliminary to breeding varieties which do not bolt under Scottish conditions.

The Genetics Department has also two main objectives. The first is investigations into the inheritance of the Yellows complex in strawberries. This particular problem has assumed increasing importance in this country in the last six or ten years although it has been known as a problem to strawberry breeders for the last 30-40 years. The mode of attack is to undertake extensive reciprocal crossing between yellow and green parent material.

The second objective of the Genetics Department is to explore the use of ionising radiations and chemicals such as colchicine, nitrous oxide, etc. to induce mutation in our economic crop plants.

The Institute's West of Scotland Unit is located at Auchincruive. Here Mr. R. D. Reid continues his strawberry breeding work which has given to the industry Climax, Talisman and Redgauntlet. The first requirement of varieties produced by this Unit is that they shall be resistant to *Phytophthera fragariae*. It is now known that this fungus has a number of physiologic races and the indications are that this process of producing new physiologic races will continue. The urgent necessity, therefore, is to obtain new sources of resistance and these are being looked for in seedlings of polyploid strawberries and in the induction of mutation by radiation and chemical treatment.

### Hill Farming Research Organisation, Edinburgh.

The growth of *Trifolium repens* is being studied in relation to pH and exchangeable calcium, and the characteristics of the hill-

pasture genotypes of clovers and the indigenous strains of *Rhizobium* are under study.

Investigation is being made of the edaphic conditions favouring growth of *Molinia caerulea*. With regard to heather, genotypic variation among regional populations of *Calluna vulgaris*, effects of frequency and period of grazing on growth form and yield, regeneration after burning and problems of nutrition are all under investigation.

A study of the grazing behaviour of hill sheep, begun in 1956, is being continued, as are long-term studies on the effect of different frequencies of muirburn on heather and *Molinia* communities. The effect of different drainage régimes on the growth of plants on peat, and the rate, amount, and chemical composition of run-off from open-drained peat areas receiving different treatments are being measured.

Improvement of hill pastures by methods other than ploughing (e.g. harrowing, the muirfad technique, herbicide treatment) and the value of different species and strains in such improvements are under investigation.

THE MACAULAY INSTITUTE FOR SOIL RESEARCH, ABERDEEN.

In the Department of Pedology botanical work is associated with the Soil Survey of Scotland and with studies in Peat Ecology. Vegetation surveys of a general nature have been carried out during the past few years on areas where systematic mapping of the soils had already been undertaken. The areas surveyed botanically and reported on are Third Edition Ordnance Map, Sheet 22 (Kilmarnock) and Sheets 25 (Kelso) and 26 (Berwick-upon-Tweed). From these vegetation surveys the main communities, woodland, grassland, heath, marsh and peat vegetation, are described and the correlation between vegetation and the major soil groups is demonstrated.

The work on peat ecology concerns: (1) the general ecology of Scottish peat deposits, studies on the botanical, chemical and physical characters of bog profiles and the investigation of other environmental factors, including water regimes, which control the floristic composition and distribution of plant communities on the bog surface. (2) The application of the results of ecological research to problems concerned with the classification and nomenclature of peat and peat deposits.

In association with the stratigraphical studies, the pollen analysis of samples from a wide range of deposits and profiles is in progress. The results obtained give a useful picture of the post-glacial history of the Scottish flora and of past environmental conditions. In association with the Scottish Peat Committee, attention is also being paid to the more practical aspects of bog reclamation, and to problems concerned with the general ecology and improvement of upland grazings, with emphasis on the reaction of Calluneta and related types to different intensities of burning, grazing and manuring.

Research undertaken by the Department of Plant Physiology includes: the interaction of major elements in plant leaves with special reference to the phosphorus-iron ratio, the uptake of micronutrients as affected by chelating agents, the respiratory and metabolic changes in discs of storage tissues of varying width maintained at different temperatures and their varying sensitivity to respiratory inhibitors, and the cation exchange of plant roots in relation to various regimes of nitrogen and phosphorus.

### The Rowett Research Institute.

Experimental work is being carried out on the proteins and related compounds of leaves, but this is mostly still in the exploratory stage. The metabolic role in the leaf of some of the bound non-protein amino acids has been clarified by the use of a radioactive tracer.

The concentrations of nitrogen and chromogen in the faeces of grass-fed cattle as indicators of the digestibility of the grass are being studied. Data obtained from the work are now being used to estimate the quantities and quality of herbage consumed by grazing dairy cows.

### Scottish Marine Biological Association.
### Marine Station, Millport, Isle of Cumbrae.

Of the eleven members of the Scientific staff, one (Dr. M. R. Droop) is a microbiologist and another (Mr. H. T. Powell) is a phycologist.

Dr. Droop's main field of work is the nutrition of marine micro-organisms. He has determined the thiamine requirements

of several marine and supralittoral protista in bacteria-free culture. An investigation of vitamin $B_{12}$ requirements of the flagellate *Monochrysis* led him to the conclusion that this vitamin is probably never a limiting nutrient for phytoplankton in the sea. The nutritional requirements of some Chlorophyceae derived from rock pools and of the diatom *Skeletonema costatum* are being investigated.

Dr. Droop has published the following Papers during 1958:

Droop, M. R. Optimum relative and actual ionic concentrations for growth of some euryhaline algae. *Verh. int. Ver. Limnol.*, 1958, **13**, 722.

Droop, M. R. Requirement for thiamine among some marine and supra-littoral Protista. *J. mar. biol. Ass. U.K.*, 1958, **37**, 323.

Mr. Powell's work lies in the field of shore ecology and taxonomy of marine algae. Ecological surveys have been carried out in the Firth of Clyde and on the West Coast, particularly in the Loch Sween area, and a study of the taxonomy and geographical distribution of species of the genus *Fucus* is in progress. Mr. Powell also took part in the Glasgow University Expedition to North Rona and Sula Sgeir and investigated the marine and terrestrial flora of those islands. The following note has been published and further publications are contemplated:

Powell, H. T. Occurrence of forms of *Fucus distichus* L. emend. Powell on North Rona and Sula Sgeir. *Nature, Lond.*, 1958, **182**, 1246.

Further information on the Association's work in botany and in other fields of marine science can be obtained in the Annual Report (free to members, price to non-members 4/-). It should also be mentioned that in the Association's Oceanographic Laboratory, 78 Craighall Road, Edinburgh, 5, which is mainly engaged on an investigation of the biology and distribution of plankton in the Atlantic and in the North Sea, using sampling equipment towed by commercial vessels and weather ships, Mr. G. A. Robinson is studying the distribution and fluctuation in numbers of several species of diatom.

### The Nature Conservancy, Edinburgh.

*Vegetation Survey.*—Part 1 of the vegetation survey of the Scottish Highlands is completed and will be published by the

Nature Conservancy in 1959. This consists of a systematic and quantitative description of most of the terrestrial plant associations of the Highlands together with floristic lists, distribution maps and soil analytical data.

Part 2 of the survey will consist of regional descriptions of Scottish terrestrial vegetation in terms of the units defined in Part 1, with notes on present land use and its effect on soil and vegetation.

*Relationships of climate and vegetation.*—The vegetation survey has suggested certain relationships between e.g. climatic oceanicity and floristic composition of many plant associations. These are now to be examined in greater detail, experimentally where possible.

*Scottish woodlands.*—The native and quasi-native woodlands of Scotland have been mapped on the scale of 10 miles to the inch and a reconstruction attempted, on the same scale, of the forest cover of the country before the major deforestation activities of the historical period. Research is mainly being applied to the problem of woodland reserve management and the production of woodland or scrub on present moorland and blanket bog by planting and direct seed sowing. The tree and shrub species at present involved are as follows:

*Pinus sylvestris*—Autecological studies. Rehabilitation of derelict woodland by planting and direct sowing. Direct sowing on deforested ground.

*Alnus glutinosa*—Direct sowing on blanket bog.

*Betula pubescens*—Direct sowing on moorland.

*Fraxinus excelsior*—Autecological studies. Rehabilitation of derelict woodland.

*Quercus robur* and *Q. petraea*—Work is to begin shortly along the lines already followed for *Pinus*.

*Sorbus arranensis* and *S. pseudofennica*—Raising seedlings for planting out in Glen Diomhan Nature Reserve, Arran.

*Ulex europaeus*—Direct sowing on moorland as pioneer species.

*Moorland deterioration and soil erosion.*—Changes taking place in certain moorland communities following the cessation of rotational burning are being followed. Various experimental treatments are being carried out in connection with the woodland establishment programme.

Work will shortly be started on the vegetational stabilisation of actively eroding hillsides in the island of Rhum.

## II. Colleges.

### The West of Scotland Agricultural College Botany Department.

Four main lines of research work are being followed in this Department.

(1) *Growth regulators and legumes.*—The effect of growth-regulators on the growth and nodulation of clovers (*Trifolium* spp.), and on the growth and infective power of rhizobia. The growth regulators being tested are substituted phenoxyacetic and phenoxybutyric acids; phenoxypropionic acids; dalapon; and gibberellic acid. The following papers have been published on these investigations: —

*Nature, Lond.*, **177**, 1244 (1956); **178**, 151 (1956); **182**, 1319 (1958); *Phyton*, **7**, 121 (1956); **9**, 41 (1957).

(2) *Bracken Research.*—(a) Studies on the translocation of growth regulators in the bracken rhizome. This work (which will form the basis of a Ph.D. thesis) is being carried out in conjunction with the Agricultural Research Unit, University of Oxford. The movement of the growth-regulators is being assessed by noting the morphological and anatomical changes induced at the rhizome apices and by a radioautographic technique using labelled compounds.

(b) Field trials to assess the effects of various herbicides on bracken have been carried out. The majority of these have been in the nature of screening tests to ascertain the action of the chemicals on the rhizome, and also to ascertain their possible use for the control of bracken before carrying out large-scale field trials. The following paper has been published on these investigations: —

*Proc. Third Brit. Weed Control Conf.*, 255 (1956).

(c) In conjunction with the Scottish Station of the National Institute of Agricultural Engineering, trials of the effect of various bruising and cutting machines on the growth of bracken have been carried out from 1952-1955. The results have been summarised in a recent College bulletin, *Research Bulletin*, 24 (1958).

(3) *Epidermal Patterns.*—The epidermal cells of any plant impress a particular pattern upon the cuticle of the plant and by examining the cuticle under the microscope it is possible to identify the species of plant from which it was taken. A collection of epidermal patterns of the British legumes is being prepared. A study is also being made of hill-sheep diet by examination of epidermal fragments in the faeces. Monthly samples have been taken from 4 ewes and their lambs on a heft of full range from sea-level to 1,200 ft. and from 4 ewes and their lambs on a heft restricted by afforestation to grazings over 500 ft. A preliminary report of this work appeared in *Trans. Bot. Soc. Edinb.*, **36**, 278 (1954).

(4) *Drawings of British Legumes.*—A series of drawings of British Legumes is being prepared. Each drawing will comprise the mature plant, flower parts, fruit, seed, seedling, pollen grain and cuticle pattern. Some twenty drawings have now been completed.

## The West of Scotland Agricultural College. Department of Plant Pathology, Auchincruive.

*Physiology of disease severity.*—Certain fungal diseases do not attack their host plants at certain stages of growth, and growth cycle analyses revealed the fact that the host plants were growing rapidly and had relatively little carbohydrate at the times of non-attack. The two factors are specifiable jointly by the Cp/Rs ratio—the weight of total carbohydrate in the whole plant divided by the residual dry weight of the shoot (Grainger, *Phytopathology,* 1956, **48**, 445). The higher the Cp/Rs ratio value the higher the disease potential of the plant and vice versa. Disease potential is related to host plant physiology and not to its genetic make-up, hence the terms 'susceptible' and 'resistant' are not used. Ratio values explain all known facets of the epidemiology of potato blight (Grainger, *Agricultural Review,* Oct. 1957). During the present year the ratio values have been used to explain the relations of turnips and swedes to attack by the club root fungus *Plasmodiophora brassicae.* They do so, but preliminary indications suggest that a better assessment of host physiology in relation to attack

by the fungus could be obtained if nitrogen were also considered with this particular disease.

The results have practical value for glasshouse tomatoes, for the prevention of any check to growth during transplanting keeps the Cp/Rs ratio low and renders the plant of low disease potential.

*Disease forecasting.*—The Auchincruive self-calculating blight forecast recorder has been developed to specify, without calculation, the weather conditions suitable for an attack of potato blight (Grainger, *Weather,* 1955, **10**, 213). Here again, however, more precision could be added to the forecasts if the Cp/Rs values of the crop could be measured at the time a weather forecast becomes valid.

*Soil disease control by mixing.*—A method and machine for the intimate incorporation of dust containing yellow oxide of mercury was developed for the control of potato root eelworm. It has been tried this year against club root disease of turnips and swedes, and gives 96-98% control of the disease and 50-55% increase in yield on susceptible varieties.

*Bacterial diseases of plants.*—Dr. Marjorie Clark has described a bacterial disease of dahlias (*Plant Pathology,* 1956, **5**, 32). The work is being continued as opportunity offers, particularly as it affects bacterial diseases of the chrysanthemum.

The Department's activities include a large amount of advisory work to farmers and growers and smaller amounts of research arising from this work are also investigated.

### West of Scotland Agricultural College, Grassland Husbandry Department, Auchincruive.

*Evaluation of Grass and Clover Strains.*—(a) The agronomic value of commonly used strains of the principal grass species is being assessed by monthly harvests with a motor mower. Under trial are 12 strains of perennial ryegrass, 12 strains of cocksfoot, 3 strains of tall fescue and 3 of meadow fescue. The strains are tested under two levels of applied nitrogen; no nitrogen and 12 cwt. nitro-chalk per acre per annum.

(b) Nine strains of Italian ryegrass, including three Westernwolth types and New Zealand short rotation (H.1) ryegrass were sown under oats in 1957, and have been compared for early bite,

forage production and nitrogen response during 1958. Times of harvesting have been varied to assess the effect of maturity on herbage quality.

(c) The yields of four strains of white clover have been measured over three years, growing alone and in combination with cocksfoot, perennial ryegrass and timothy.

(d) An experiment has been established to compare the effects of season and age on production from grass species of agricultural importance. Thus, successive sowings are being made of the same species every year. The interaction of age of the stand and the season can then be calculated.

(e) The competition between early, medium and late-maturing strains of perennial ryegrass is being investigated in a series of experiments from which the growth curves of the various strains in all combinations may be obtained.

(f) The production from tall fescue sown at various rates and in combination with other grasses will be recorded during the next three years. The objective is to find an economical mixture retaining the early growth characteristics of tall fescue but with rather better first year ground cover.

(g) Records have been kept for four years of the productivity of 27 strains and species of grass growing on upland blanket peat. Many "natural" grasses such as red fescue are included in this trial.

*Manuring.*—(a) The time and form of nitrogenous fertilizer application to produce early grass growth is being investigated in a series of cutting trials.

(b) The manurial response of perennial ryegrass and yorkshire fog has been compared on an undrained hill peat site.

(c) The response of white clover to nitrogen, phosphate and potash has been recorded over the past three years. The effect of the various manurial treatments on ash components is being examined spectrographically.

*Improvement of Hill Land.*—(a) Sowings of white clover have been made monthly on undisturbed hill herbage in an attempt to find the most advantageous time for establishment. Lime and slag are applied as a pre-treatment.

(b) The value of pelleting white clover seed with lime and slag as an aid to establishment on hill ground is under trial.

(c) As a pre-treatment to oversowing, a new chemical (Dalapon) which renders the existing herbage dormant has been used. By eliminating the natural vegetation a better establishment of grasses and clovers can be obtained.

*Miscellaneous.*—(a) Extension of the grazing season by sowing a species with a different growth cycle into an existing sward has been obtained. Future investigations will concentrate on developing a machine which will function on varying sward types and on determining the correct species and time of sowing.

(b) Climatological studies are being carried out on lowland and upland sites. These will be related to grass growth.

(c) Experimental techniques which bring the animal influence into strain trials are being investigated. If such an inexpensive method can be devised the value of strain testing for advisory work will be greatly enhanced.

### Edinburgh and East of Scotland College of Agriculture.

General research has included a study of yields given by different strains of perennial ryegrass, cocksfoot and white clover, and examination of the performance of pasture grasses on different types of soil and with different manurial treatments. The effects of level of nitrogen usage under a rotational grazing system have been further investigated, and results indicate that in terms of grazing days and live weight gain per acre the control was poorer than either of the two rotational methods. In practice, however, the rotational system might not be outstandingly advantageous when considered in relation to the possible extra cost and labour involved. Assessment is being made of the nitrogen-fixing capacity of clovers under various conditions and of the effects of animal excreta on pastures. Trials have been carried out with thirty-six different herbicides, with subsidiary tests of the efficacy of wetting agents and the avoidance of spray drift. Work has recently been started on control of aquatic weeds.

Dr. Harper has completed a survey of the relationship of plant distribution to soil factors in an area in the Lammermuir Hills.

In the Plant Pathology division research continues on potato blight, skin spot and dry rot. Sugar beet strangles did not reach serious proportions in 1958, and incidence of the disease could be raised experimentally by heavy application of water to newly-singled plants, or reduced by application of the water before singling. Bacterial canker of plum can be greatly reduced by treatment of the stem with an emulsion paint containing streptomycin. Various types of seed dressing are being intensively studied.

### North of Scotland College of Agriculture.

In the Botany Department weed ecology is being studied, and, additionally, the use of selective weedkillers for weed control. Particular interest is being taken in the distribution and control of corn marigold (*Chrysanthemum segetum*), broom (*Cytisus scoparius*), and whin (*Ulex europaeus*).

Mycological investigations in progress are concerned mainly with storage rots of potatoes and diseases of turf and pasture grasses. In recent trials with tomatoes, *vapum,* used as a soil drench, gave good control of foot-rots, potato root eelworm and weeds.

Some Dutch turnip varieties of good quality showed resistance to club root.

Dieback of hybrid tea roses would appear to be associated with infection of the briar stocks by the canker fungi, *Coniothyrium wernsdorffiae* and *C. fuckelii.*

### Royal College of Science and Technology, Glasgow.

Some years ago, during alterations in the College, an old herbarium was discovered, which related largely to a collection made by Dr. John Scouler, a forgotten minor naturalist of the early nineteenth century. His herbarium is now being rehabilitated and his life and work are being studied by Dr. Blodwen Lloyd.

A detailed study is being made of the germination of the basidiospores of the common mushroom, *Agaricus campestris,* by Miss McTeague. Particular attention has been given to the stimulation of germination of these spores by mycelium of the same species, first noted by Ferguson in 1902. This stimulation

reduces the germination time of the spores from approximately three weeks to one week. Some study has also been made of the factors affecting the growth of mycelium of *A. campestris*.

Work has recently been begun by Mr. D. McLeod on host-parasite relationships in Angiosperm parasites, with particular reference to *Cuscuta* spp. Earlier work was largely done from an anatomical and morphological viewpoint; some extension of this has been accomplished, particularly on the nature of the haustorium. Future work will involve a physiological study using radioactive tracer technique to help resolve problems such as the nature of the absorbed nutrients. Experimental work on the conducting system of *Cuscuta* stem is at present in progress.

## Heriot-Watt College, Edinburgh.

Botanical research in the Heriot-Watt College has been principally concerned with the carbohydrate composition and metabolism of grass seeds, with especial reference to the common cereals. Dr. A. M. MacLeod and Dr. Hugh McCorquodale have completed a preliminary survey of the sugars and water-soluble polysaccharides of British grass seeds, and some interesting relationships have been observed between carbohydrate content of the seeds and the natural classification of the Gramineae. Professor Preece and Dr. Myra MacDougall have carried out a comprehensive study of the breakdown of pentosans during cereal germination, and results of this work, taken in conjunction with earlier studies by Dr. Hoggan on enzymolysis of $\beta$-glucan, have provided a reasonably clear picture of enzymic potentialities for the hydrolysis of less resistant hemicellulose components of the barley endosperm. Dr. Garg is completing this series of investigations by examining the intermediate products of $\beta$-glucan enzymolysis, using both barley and oats as enzyme sources; interesting differences are apparent in the balance in different cereal grains of three different enzyme systems known to be involved in $\beta$-glucan degradation.

Although these water-soluble polysaccharides ($\beta$-glucan and pentosan) are of considerable importance in barley germination and, therefore, in malting, it seems that pectic substances are virtually absent from the barley endosperm, though present in

the meristematic embryo. The absence of pectin from the middle lamella of *Bromus sterilis* is attested by the ready separation of individual endosperm cells in water, but the precise nature of the intercellular cement of cereal endosperm has not yet been established with certainty.

With a reasonable body of information available regarding the more soluble polysaccharides, attention is now being directed to degradation of the insoluble polysaccharides such as hemicelluloses, and for this purpose *Bromus mollis* is proving an admirable enzyme source. The massive cell walls of *Bromus* endosperm are of the same general composition as those of barley, and they disappear with spectacular suddenness after about three days of seedling growth. It is hoped that studies of the hemicellulases of *Bromus*, now being carried out by Mr. Sandie, will go some way towards elucidating the changes undergone by the more resistant endosperm wall components during germination.

In addition to these investigations on grasses, which have provided the main research topics for the past five years, Dr. Rose has begun work on the metabolism of biotin in yeasts, and on the physiology of film-formation by yeast cells.

Papers published recently include the following:—

Preece, I. A. Cereal carbohydrates: *R.I.C. Lectures, Monographs and Reports*, 1957 (ii).

Preece, I. A., and Hoggan, J. Carbohydrate modification during malting. *Proc. Eur. Brew. Conv., Copenhagen*, 1957, 72.

Preece, I. A., and MacDougall, M. Autolysis relationships of barley pentosans. *J. Inst. Brew.*, 1957, **63**, 520.

Preece, I. A., and MacDougall, M. Enzymic degradation of cereal hemicelluloses: pattern of pentosan degradation. *J. Inst. Brew.*, 1958, **64**, 489.

Preece, I. A., MacDougall, M., Darby, O., C., and Steven, I. Non-starchy polysaccharides of cereal grains. Further studies on autolysis. *J. Inst. Brew.*, 1958, **64**, 489.

MacLeod, A. M., and McCorquodale, H. Comparative studies of embryo and endosperm. *J. Inst. Brew.*, 1958, **64**, 162.

MacLeod, A. M., and McCorquodale, H. Water-soluble carbohydrates of seeds of the Gramineae. *New Phytol.*, 1958, **57**, 168.

MacLeod, A. M., and McCorquodale, H. Trisaccharides of *Lolium* and *Festuca*. *Nature, Lond.*, 1958, **182**, 815.

## III. University Botany Departments.

### University of St. Andrews.

A check list of marine algae occurring in St. Andrews Bay is now almost complete, and ecological work continues on seasonal variation in growth and reproduction of the algae in this area. In addition, a number of species of Phaeophyceae are at present in culture and, in particular, an intensive study is in progress on different forms of *Pilayella littoralis* both in culture and in nature. Investigation into the respiratory metabolism of *Fucus vesiculosus* has also been made.

Cytotaxonomic work is in progress on a number of mosses and the results of this will be published shortly.

Ecological work is principally concerned with serpentine vegetation. Investigations in the field are under way at the serpentine outcrop at Meikle, Kilrannoch, and experimental investigation of the "serpentine effect" both on serpentine adapted and non-adapted plants is in progress in the greenhouses. Work has also begun on the salt uptake and water balance in a range of saline and dune plants. A survey of the vegetation of Scottish lochs has also been begun.

Mycological work is in progress on a wide range of problems in fungi. They include cytological work on the nuclei of Basidiomycete fungi and on meiosis in certain agarics; life cycles of a number of Scottish rusts and of *Protomyces macrosporus*; and the organisation and genetics of Basidiomycete mycelium. This latter topic includes investigation of rhizomorph development in *Marasmius androsaceus,* the distribution in space of fungal mating-type factors, and the genetical and physiological control of clamp formation and nuclear migration.

The following papers have been published during the year:

Burnett, J. H., and Partington, Margaret. Spatial distribution of fungal mating-type factors. *Proc. Roy. Physical Soc. Edinb.*, **26,** 61.

Chambers, J. A., and Burnett, J. H. Respiratory system of *Fucus vesiculosus*. *Annual Report of The Challenger Society,* 1958, 3, No. X.

Macdonald, J. A. Two biological races of *Uromyces lineolatus* (Desm.) Schroet. *Trans. Brit. mycol. Soc.*, **41**, 178.

Macdonald, J. A. Some Aspects of our Knowledge of the Fungus Cell. Presidential Address. *Trans. Bot. Soc. Edinb.*, **37**, 146.

SPENCE, D. H. N. Studies on the Vegetation of Shetland, I. The Serpentine Debris Vegetation in Unst. *J. Ecol.*, **45**, 917.
SPENCE, D. H. N. The Flora of Unst, Shetland, in Relation to the Geology. *Trans. Bot. Soc. Edinb.*, **37**, 163.

Research work in the department has been assisted by the provision of experimental greenhouses for ecological or physiological work and will be further enhanced with the completion of the new extension to the Gatty Marine Laboratory this session which will provide laboratories for work in marine botany. The field station at Glen Doll is also to be rehabilitated and will provide laboratory facilities within striking distance of the Angus hills.

## UNIVERSITY OF GLASGOW.

Palaeobotanical investigations have been carried out under the supervision of Prof. J. Walton by a number of research students including the following: Miss M. Reyman (Cracow), working on Bennettitalian cones; K. U. Leistikow (Tübingen) on *Astromyelon*; Dr. J. Sen (India) on Carboniferous *sporae dispersae*; H. R. N. Eydt (McMaster) on pollen analysis of peat from the Campsie Fells; D. L. Smith on the Lower Carboniferous flora of the Kilpatrick Hills; D. W. Brett on fossil dicotyledonous woods from the Eocene.

B. W. Ribbon's work is on the flora of Scotland and includes an account of Renfrewshire for the Statistical Account, the genus *Ledum*, vice-county boundaries, and plant recording for the Distribution Maps Scheme. A. C. Crundwell has continued his taxonomic work on British, Scandinavian and arctic Bryophytes. He is also collaborating with E. F. Warburg in the preparation of a new British moss flora. The sporelings of *Isoetes australis* and the complex growth processes in the stock of *Isoetes* spp. are being investigated by S. Williams.

E. Conway is working on the supra-littoral algal zones on northern shores. In particular, the zone of *Porphyra* is under review in an ecological and taxonomic study of this genus. An investigation of the occurrence and ecological importance of nitrogen-fixing and other blue-green algae in the supra-littoral zone is being undertaken by W. D. P. Stewart.

G. D. Scott is continuing his work on nitrogen fixation by the primary and secondary phytobionts of the lichens *Peltigera prae-*

*textata* and *Stereocaulon ramulosum*. The conditions necessary for the synthesis of lichens in pure culture are also being studied. G. Bond and associated research students have continued their investigations on nitrogen fixation in non-Leguminous root-nodule plants.

Research Mycology, under S. A. Hutchison, has centred round the following problems: host reactions to parasitism, the periodicity of spore discharge in the Basidiomycetes, spore germination in *Agaricus campestris,* and, in conjunction with the West of Scotland Asthma Clinic, the relationship between the air-borne spores of *Merulius lachrymans* and allergic asthma. G. Hadley is investigating the effect of light on the sporulation of *Trichoderma viride.*

E. Conway (in collaboration with J. D. Forrest) has continued an investigation into the effect of herbicides on *Pteridium aquilinum.* It has been established that a number of phenoxyacetic acid compounds are absorbed by the leaves and translocated to the tips of the adjoining stem branches, where they induce morphological and anatomical changes which are now being further investigated.

In the Agricultural Botany section A. M. M. Berrie is examining some aspects of the germination of *Pisum sativum.* It has been found that the conditions to which the seeds are exposed during germination, particularly anaerobic conditions, alter the normal pattern of subsequent growth. D. D. S. Brennan is investigating the physiology of germination of some species of *Avena.* Work is in progress to determine if germination is reversible, to study the effect of various treatments on breaking dormancy, and to follow the course of mobilisation of food reserves in the endosperm.

### University of Aberdeen.

Studies in orchid mycorrhiza are being continued by Dr. Downie, including an investigation of the effect of strains of *Corticium solani* on seed germination in various orchids. Breeding experiments on oats and swedes and theoretical studies in biometry are being carried out by Mr. Faulks, whose new book, *An Introduction to Ethnobotany,* has recently been published. Dr. Stirling is undertaking studies on the respiration of roots and

Dr. Burns is examining the cytology of floral aberrations in *Cardamine pratensis*. Experimental studies of floral morphogenesis in *Primula* and ontogenetic investigations of the shoot apex in ash and other trees are being prosecuted by Dr. Cusick. Ecological research conducted by Dr. Gimingham is centred on the vegetation of Scottish heaths with special reference to the autecology of *Calluna vulgaris* and other constituent species, including bryophytes and lichens, and comparisons are being drawn with north-west European heath communities. Miss Whittaker is engaged on a comprehensive survey of the effects of fire on heath vegetation and the problems of regeneration. Dr. Ferreira is continuing his detailed work on the vegetation of mountain habitats in Scotland and Mr. Pardy is dealing with some aspects of the ecology of bryophytes. Dr. Pritchard is occupied with taxonomic and biometric studies in *Gentianella*, and work on Craib's *Florae Siamensis Enumeratio* is being continued by Dr. Barnett, an account of several families being ready for publication. Mrs. Sommerville is engaged in the collection of material with a view to a revision of *The Botanist's Guide to the Counties of Aberdeen, Banff and Kincardine*, published in 1860 by Dickie, Kincardineshire being dealt with first. In this project assistance is being given by several local botanists.

## IV. The Royal Botanic Garden, Edinburgh.

The scientific work of the staff of the Royal Botanic Garden, Edinburgh, is essentially of a taxonomic-biological nature. Mr. B. L. Burtt is studying the Old World members of the family Gesneriaceae, the genera *Crocus* and *Colchicum*, the Asiatic members of the genus *Heliotropium* and other ornamental plants. Mr. P. S. Green is investigating the family Oleaceae, with special reference to the genus *Osmanthus* in Malaysia and to the genus *Notelaea* (sens. lat.). In conjunction with Mr. L. A. Lauener, Mr. Green is also engaged in the revision and cataloguing of the Léveillé Herbarium. Mr. A. G. C. Grierson is studying the genus *Incarvillea*; additionally his studies in the Compositae are at present directed particularly to the *Chrysanthemum-Tanacetum* complex.

Turkish Labiatae and Cruciferae are being investigated by Mr. I. C. Hedge, who is also studying the genus *Salvia* in south-west Asia, with special reference to the occurrence of sex forms. The *Anemone obtusiloba* complex is being examined by Mr. L. A. Lauener, and *Buddleia* and *Rhododendron* are being studied by Mr. J. Keenan and Mr. H. H. Davidian respectively.

Work on cryptogams is being carried out by Mr. D. M. Henderson, who is currently engaged in studies of the smut genus *Cintractia,* the rust fungi of the Uromyces group parasitic on *Trifolium,* the fungi of Scottish mountains, and the Bryophytes of Turkey and Persia.

Horticultural research by Mr. E. E. Kemp is devoted to a study of the response of cuttings to mist spraying propagation treatment. Mr. Kemp is also investigating the possibility of adapting a commercially-available type of centrifuge humidifier for the humidification of Plant Propagation House atmospheres.

No Index is provided for this Volume. A Collective Index will appear on the completion of three Volumes of the *Transactions*.

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